JAN 6 1942

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PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 152—No. 3961. *LONDON: FRIDAY, DECEMBER 12, 1941.* *Registered at the General Post Office as a Newspaper* PRICE 1s. BY FOREIGN POST 1s. 2½d.

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1409

THE RANNEY SYSTEM OF UNDERGROUND-WATER COLLECTION.

THE collection of underground water by driving vertical wells is probably as old as civilisation. Modern developments have enormously increased the depth to which well sinking may be carried and in London, for instance, there are hundreds of wells bored through the clay overburden into the water-bearing chalk below. In some circumstances, determined by the nature of the underground strata, vertical wells furnished with a screen at the bottom prove to have a relatively short life. At the works of the Timken Roller Bearing Company, in Canton, Ohio, vertical wells, 2 ft. in diameter, sunk into gravel and sand beds of glacial origin, of an average depth of 120 ft., were found to have a life of only from three to eight years. The water is very hard and caused such rapid incrustation of the screens that the capacity of the wells was reduced to such a point that they had to be abandoned. It was thought that the incrustation was due to the liberation of dissolved carbon dioxide, resulting from the reduction of pressure or change in temperature. The changes decreased the solvent power of the water, with the result that a proportion of the dissolved mineral salts was deposited on the screen. Decrease in the capacity of wells also occurs owing to the silting-up of the water-bearing strata in the vicinity of the screen. This effect is likely to take place sooner than would otherwise be the case if the flow of water to the well is rapid.

When large quantities of water are required, the number of vertical wells has to be correspondingly large. Each requires its own pumping installation and independent supervision and maintenance. Construction costs per gallon of water delivered are also higher for a number of wells of relatively small capacity than for a few of larger yield. It is the purpose of the Ranney system of underground-water collection to meet these conditions by enabling one well to drain a large water-bearing area and ensuring that the velocity of flow of water to the collectors is so low that the transport of the finer particles is minimised and choking of the area immediately around the collecting screen prevented or delayed. The system also permits the flushing of the ground round the collectors. It is claimed that one Ranney collector can produce as much as ten vertical wells in the same formation. The 2-ft. vertical wells at the Timken plant produced about 2,000 gallons per minute when new. They were replaced by a Ranney well, 12 ft. 6 in. in diameter, which has a capacity of 11,600 gallons per minute. It is considered that the potential capacity of the well is greater than that of the maximum pumping capacity that can be installed.

Although the Ranney system of water collection is operated by the Ranney Water Collector Corporation, 72, Wall-street, New York, the activities of which have been mainly confined to the United States, one of the earliest applications of the system was made in this country. A 12 ft. 6 in. diameter Ranney well was sunk at Sunbury Cross in 1934 in connection with the London water supply. This well is 22 ft. deep and penetrates an alluvial bed of sand and gravel overlying the clay. It has a capacity of 1,800,000 gallons a day. This plant has been surpassed in output by a number of American installations. The capacity of most of the plants in the United States, however, is roughly of the same order of magnitude as that at Sunbury Cross. The capacity of all previous installations has now been far exceeded by that which has just been completed for the Indiana Ordnance Works at Charlestown, Indiana. In this case, seven 13 ft. diameter wells have been sunk alongside the Ohio River, the installation having a capacity of 63 million gallons a day.

A Ranney water collector consists essentially of a vertical well closed at the bottom and provided with a series of horizontal perforated collecting pipes radiating from it into the water-bearing strata. The arrangement is illustrated diagrammatically in Figs. 1 and 2, on this page. The radiating pipes in the first of these figures are shown all at one level, but if desired they may be distributed over various horizontal planes. Owing to the large collecting area provided, the velocity of flow through the screens formed by the pipe perforations is low, so that choking due to the accumulation of the finer particles in the strata round the screens is not anticipated. As the rate of flow approaches that of slow filtration, it is claimed that thorough bacteriological purification is obtained. Depending on the size of the well, from ten to twenty collecting pipes can be installed. Under favourable conditions, these may be extended to distances as great as 300 ft. from the well, although, in general, collecting pipes from 100 ft. to 200 ft. long have

Fig.1.

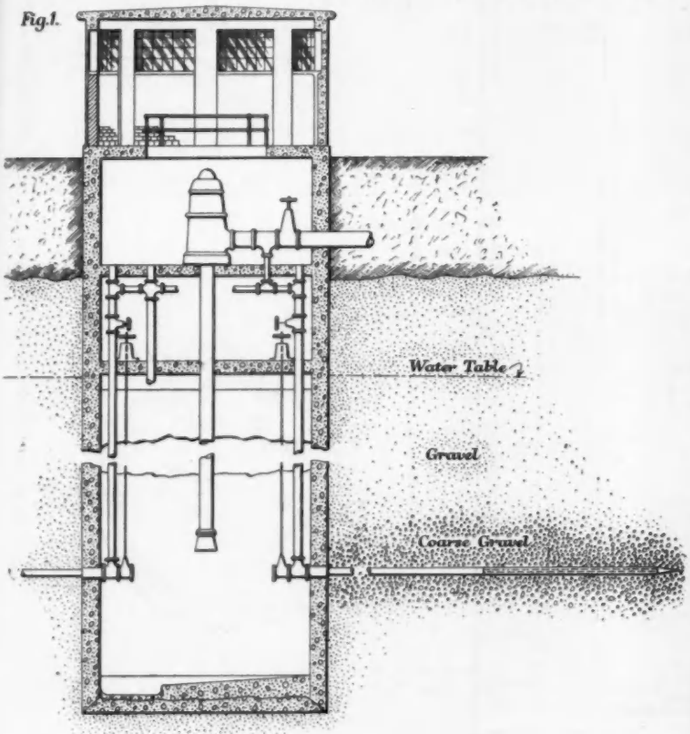


Fig.2.

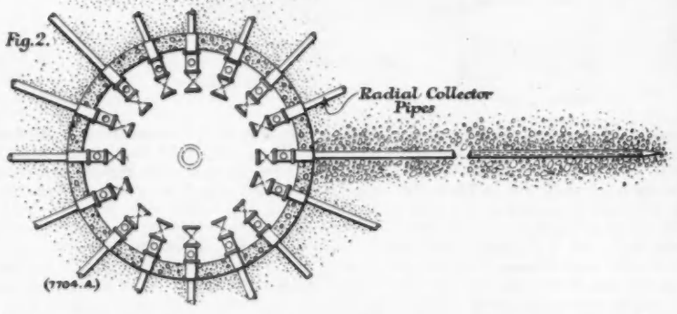


FIG. 3. BORING HEAD ON COLLECTING PIPE.

FIG. 4. COLLECTING PIPE SECTIONS AND SCREENS.

been used. As indicated in Figs. 1 and 2, the flow from each collecting pipe may be individually controlled by a gate valve.

A Ranney well is constructed by first sinking the main shaft and then, working from the bottom of the shaft, driving the collecting pipes outwards, the pipes being made up of individual sections of convenient length which are joined-up as the work proceeds. The form of boring head fitted to the outermost pipe section is a special feature of the system. This selectively removes the fine particles from the neighbourhood of the pipes, leaving the larger material to form a gravel pack round the screens. The boring head is a hollow cast-steel cone which is welded on to the outer end of the first pipe section. It is shown in Fig. 3, on page 461. The cone is provided with an internal diaphragm, welded in place, which closes off its outer end. The diaphragm is, however, formed with a 2-in. diameter central hole. A pipe of the same diameter is inserted into this and extends forward of the pipe into the earth. The inner end of the 2-in. pipe is supported by a jacking frame in the well, the length of the pipe being increased, as driving proceeds, by adding extra sections. A number of these 2-in. pipe sections can be seen in the centre of Fig. 4, on page 461. The 2-in. pipe line is provided with a valve and as the main pipe is being driven this valve is opened so that sand and fine gravel flow from the front of the boring head, through the pipe and into the well, from which they can be pumped. It is possible to remove the fine material up to a distance of 7 ft. ahead of the position reached by the outer end of the main pipe.

This special boring head has been referred to at this stage as it is an essential feature of the Ranney method of construction, but a description of the whole system will be followed most clearly from a detailed account of an actual installation. We propose therefore to deal with that at the Indiana Ordnance Works, already referred to. The works is a smokeless-powder factory belonging to the U.S. War Department. Seven 13-ft. diameter wells, about 1,800 ft. apart, have been sunk approximately 100 ft. from the bank of the Ohio River. They vary in depth from 80 ft. to 110 ft., and the strata consists of sand and gravel. As already mentioned, the capacity is 63 million gallons a day, far surpassing that of any other installation so far constructed. The water has a temperature of about 60 deg. F. practically all the year round, and is suitable for use in processing work without filtration or other treatment.

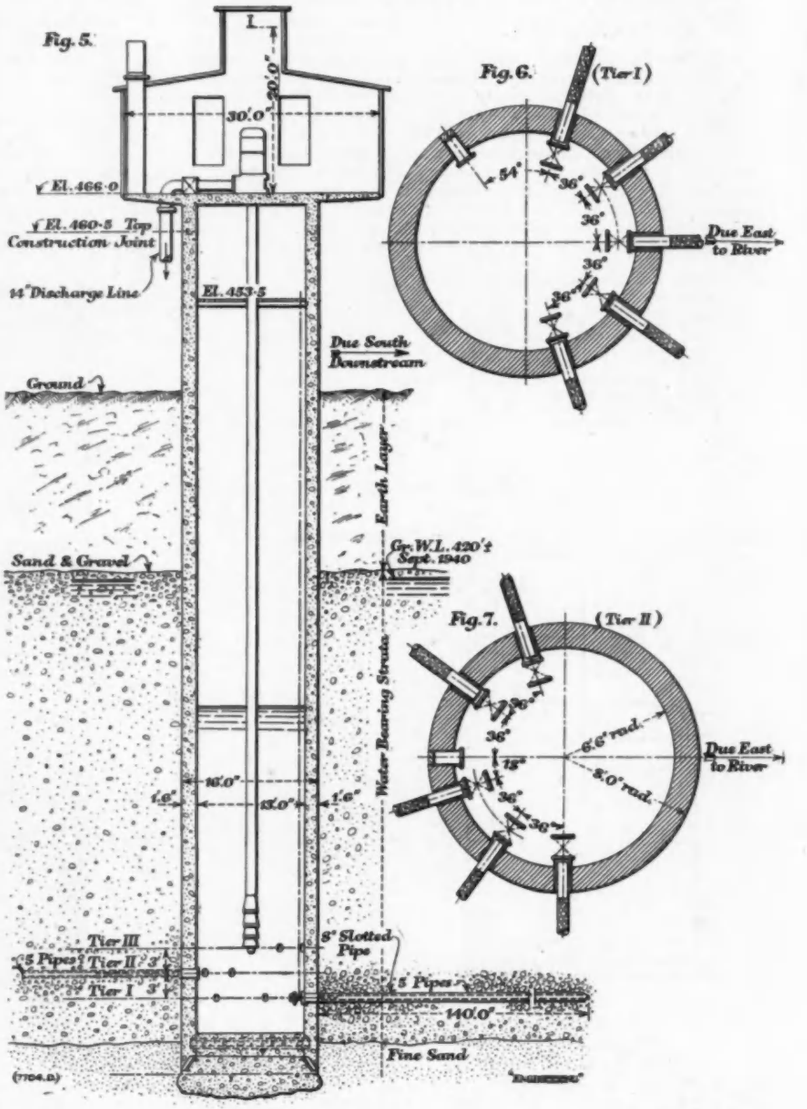
A sectional elevation and two sectional plans of one of the wells are given in Figs. 5 to 7, on this page. They are of 18-in. thick reinforced concrete. Construction of each well was carried out by building a 12-ft. section furnished with a steel cutting shoe at its lower end. This section, which, in effect, formed a caisson, was built in a sheeted pit excavated to the ground-water table; steel forms were used. Excavation was then carried out inside the caisson, using a ¾-cub. yd. clamshell bucket. When it had sunk sufficiently, the next 12-ft. section was added, and this procedure was repeated until the full depth had been reached. As shown in Fig. 5, a circumferential groove had been formed inside the first section, near the bottom, and when sinking was completed, 12 in. by 12 in. by 79 lb. reinforcing beams were placed in this groove by a diver and the bottom of the caisson was closed by a concrete plug, the concrete being placed under water by means of a tremie. One of the shafts was built in less than a month. The first section, or caisson, was formed with eighteen 10-in. diameter portholes through which the screen pipes were later driven. Two of these can be seen in the view of the caisson reinforcement given in Fig. 8, on the opposite page. A view showing the excavation of the well and sinking of the caisson is given in Fig. 9. After completion, the well was unwatered by a 600-gallon per minute pump.

Working from the bottom of the shaft, the screen pipes were then placed. These are of 8 in. internal diameter, in 8 ft. lengths. They are made from copper-bearing steel and were formed from flat plates, punched with ⅜ in. by 2 in. slots. The plates were rolled into the form of a pipe and welded after punching. They were driven in a radial direction by a pair of 6 in., 100-ton, hydraulic jacks, the reaction being taken by the wall of the caisson opposite to the porthole through which the pipe was being driven, one pipe only being inserted at a time. The hydraulic-jack rig is illustrated in Fig. 10, opposite, and it is shown in position at the bottom of the shaft in Fig. 11. As penetration proceeded, each new 8 ft. length of pipe was welded on to the one already driven. As previously explained, the fines lying around the path of the advancing screen pipe were removed by a 2 in. pipe inside it. The average fine material collected and removed from the well by pumping was 4 cub. ft. for each 1 ft. penetration of a screen pipe. With a crew of three workmen and a foreman, from four to five 8-ft. pipe sections were driven in an 8-hour shift. The longest screen pipe driven extends outward for 257 ft. In general, two men at the bottom of the well shaft operated the jacks and placed new sections in position, and the other, at the top, lowered the sections and attended to the running of the dewatering and hydraulic pumps. All welding was done by a separate gang of two men who moved from well to well as required.

In all, ten collecting pipes were driven, leaving eight of the eighteen original portholes available as spares. One or more of these can be brought into use by driving further pipes if any of the original pipes become choked. As shown in Fig. 5, the portholes are arranged in three tiers, 3 ft. apart, vertically. Five pipes have been driven from the two lower tiers as shown in Figs. 6 and 7, the upper row of portholes having not yet been used. The collecting pipes are each provided with a control valve operated from the pump house at the top of the shaft. By closing these and pumping the well dry it may be inspected and, if necessary, cleaned without difficulty. The valves, however, perform another important service. By closing all but one, and temporarily lowering the water level in the shaft, an accelerated rate of flow may be caused through each pipe in turn. This tends to dislodge any fine sand which has accumulated round the screens and restore the full capacity of any collector pipe which has shown a reduction in yield. The sand released is carried into the well and removed by pumping.

Surmounting each shaft there is a pump house containing two 20 in., five-stage vertical centrifugal pump, each having a capacity of 3,500 gallons per min. and driven by a 450-h.p. electric motor. The discharge pipes from the pump houses deliver to two 36-in. cast-iron mains serving the power plant, situated about 1½ miles away and at an elevation some 190 ft. higher. The mains are run about half a mile apart, so that accidents to one is not likely to affect the other. The general

RANNEY WATER-COLLECTING INSTALLATION.



RANNEY WATER-COLLECTING INSTALLATION; INDIANA ORDNANCE WORKS.

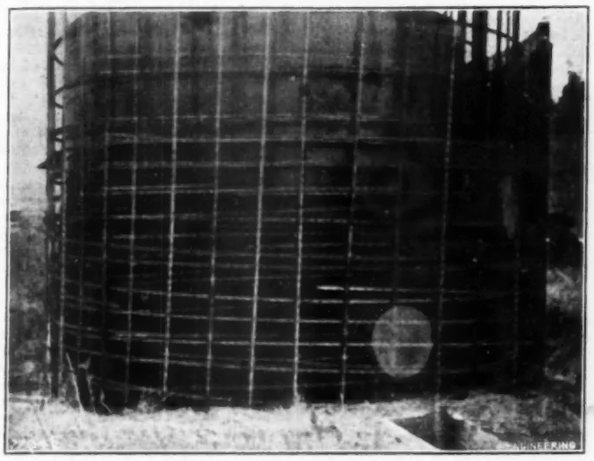


FIG. 8. CAISSON REINFORCEMENT.

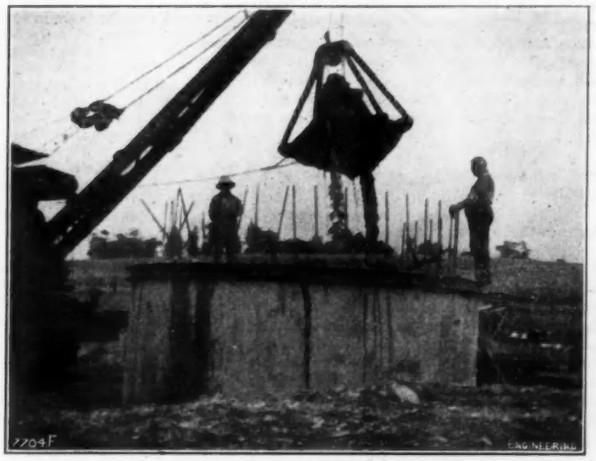


FIG. 9. CAISSON SINKING IN PROGRESS.

FIG. 10. JACKING EQUIPMENT FOR COLLECTING PIPES.

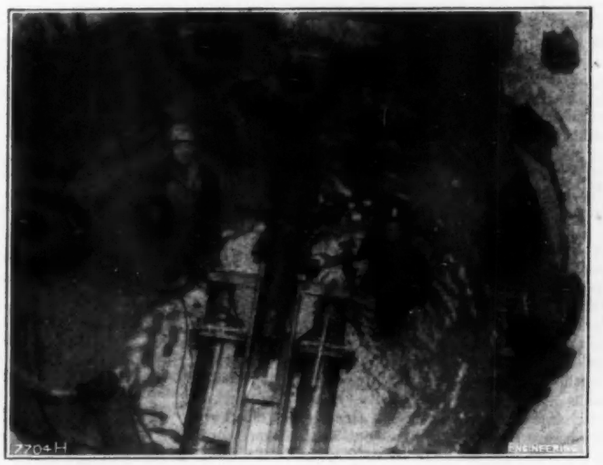


FIG. 11. COLLECTING PIPE BEING DRIVEN FROM BOTTOM OF WELL.

contractors for the Indiana Ordnance Works were Messrs. E. I. du Pont de Nemours and Company, Incorporated, the Ranney Water Collector Corporation acting as sub-contractors for the wells. The patents for the water-collecting system are held by the inventor, Mr. Leo Ranney, of whom the Corporation are licensees.

LOW-TEMPERATURE CARBONISATION COMMITTEE.—The Secretary for Mines has invited the committee which considered low-temperature carbonisation processes, last year, to re-assemble in order to examine the question of the sources of fuel for producer-gas vehicles and to estimate the quantities which could be made available at the present time. The committee, which is again to sit under the chairmanship of Lord Henley, has also been requested to report on the measures that would be required to increase the supplies of fuel for producer-gas vehicles should the necessity arise. A further matter which the committee will investigate will be whether the development of this country's peat resources would make any useful contribution to the supplies of domestic fuel in the present coal situation. The members of the committee, in addition to Lord Henley, comprise Mr. Gordon Macdonald, M.P.; Dr. W. H. Mills, F.R.S.; Mr. F. B. Richards, M.B.E., M.Inst.C.E., of the Woodall-Duckham Company; Mr. J. Shearman, M.I.A.E., M.I.Mech.E., of the London Midland and Scottish Railway; Mr. T. E. B. Young, of the Bolsover Colliery Company; and Dr. W. A. Macfarlane, who will act as secretary. Dr. F. S. Sinnatt, F.R.S., Director of Fuel Research, and Mr. J. H. Brook, B.A., of the Mines Department, will serve as assessors.

LITERATURE.

When We Build Again: A Study Based on Research into Conditions of Living and Working in Birmingham. London: George Allen and Unwin, Limited. [Price 8s. 6d. net.]

WHEN Edmund Malone, the Shakespearean critic, calling on Dr. Johnson, found him sitting by the fire and reading a history of Birmingham, he was moved to inquire, "Do you not find it dull?" "Yes," replied Johnson, "it *is* dull." Birrell, quoting the story, characteristically commented, "Happy is the man who, in the hours of solitude and depression, can read a history of Birmingham"; but neither he, nor Malone, nor Johnson—all keen observers of their fellow men—could have failed to find something of interest in this study of the conditions of living and working in Birmingham, the result of three years' research by the Bournville Village Trust. It is a co-operative work, purposely issued without any named author, and is of particular importance because, as Lord Balfour of Burleigh points out in a short foreword, the survey on which it is founded has been carried out on a regional, rather than a local, basis.

In the variety of its manufactures, the region of which Birmingham is the centre is probably unique, or, at any rate, is comparable only with London; but in many respects London represents a case apart, hardly to be considered from the same standpoint as any provincial centre of industry. In the manner of its development, however, Birmingham affords useful parallels with other great provincial centres, such as Liverpool, Sheffield, and Glasgow, and many of the conclusions reached by the investigators may serve as guides to those who, after the war, will be faced with problems of reconstruction in those areas. The survey is primarily one of the interrelation of housing and industry, but it extends beyond the mere questions of providing substitute accommodation for those, manufacturers and employees alike, who were being displaced by the operation of slum-clearance schemes before the war, and who have since been more widely scattered by the effects of enemy action. The nature of the accommodation required has also been critically examined, together with the motives which have led to congestion in particular districts and which are likely to give rise to, or to impede, the transferences to other districts.

The objection may be raised that, in the collection of data, the investigation was confined too narrowly to a particular social stratum; but, although only some 7,000 householders were interviewed out of a population of more than a million, great care was taken to make this cross-section reasonably representative. Suggestions made to relieve congestion include a strong plea for the establishment of new satellite towns; and of special interest is the proposal that, as the people of Birmingham have shown clearly their distaste for residence in flats, the space

that they demand should be provided, in part, by grouping the many small manufacturers in flats instead, in large blocks equipped with all necessary services and conveniently situated for purposes of transport. This system of grouping was one feature which accompanied the first introduction of steam power into industry, and some such buildings are still to be found in Sheffield. Eventually it was superseded, but it is conceivable that, under modern conditions, the old system may be worth re-examination.

Electric Discharge Lamps. By V. J. FRANCIS and H. G. JENKINS. London: The General Electric Company, Limited.

AMONG the spheres of electrical work in which recent years have shown remarkable development, illumination holds a high place. The first great step of relatively recent times was the complete supersession of the arc lamp, for general work, by the tungsten-filament lamp. The latter, in its turn, is now challenged by the discharge lamp. For small units, the filament lamp still appears secure in its position, but for sizes down even to 100 watts or 80 watts it is being rapidly displaced by discharge lamps of various types. The tungsten-filament lamp, although it represents a great advance on the carbon-filament lamp and still more so on such earlier illuminants as the bat's-wing gas burner, is none the less an inefficient means for converting energy into visible light. The greater part of the energy in its spectrum lies in the infra-red region; there is a little, but not much, ultra-violet. Compared with this, the spectrum of a high-pressure mercury-discharge lamp shows but a small amount of infra-red, most of the energy appearing as visible and ultra-violet light. From the point of view of illumination, this ultra-violet light is not wanted, and, indeed, is rather a nuisance; but, in spite of it, modern discharge lamps have an efficiency at least three times that of tungsten-filament lamps.

Although earlier work was done, for instance by Moore and Cooper Hewitt, it was only some ten years ago that the luminous-discharge lamp was developed to the stage at which it became suitable for its present extensive use. In its turn, this lamp has now to face the competition of the fluorescent-tube lamp. As this latest development is able to utilise some of the ultra-violet radiation in the spectrum, it might appear that it should show even better efficiencies than the vapour discharge lamp. Actually, in this respect, the two lamps are about the same; but as the fluorescent lamp is of such recent introduction, it would appear possible that future development may enable it to show an improvement on, say, the 45 lumens per watt which can be obtained from a 400-watt discharge lamp. It is mainly in virtue of the improvement in colour which is obtained that the fluorescent lamp makes such an attractive addition to the range of electric lamps available. The booklet, the title of which appears at the head of this notice, reviews the whole subject in technical detail; after dealing with the physical properties and phenomena concerned, it proceeds to a description of the constructional features of the various types of lamp concerned. As it has been written by two members of the research staff of the General Electric Company, it is naturally concerned with the products of that firm; but, in view of the large proportion of the advance in this sphere of work that has been due to the Wembley Laboratories, no better guide to this fascinating subject could be found. The work is not to be classed as a catalogue; it is a scientific treatise.

SHIPMENT OF GOODS TO AUSTRALIA.—News has been received from Australia that serious congestion of cargo still exists on wharves in the Commonwealth owing to the delay in the receipt, by consignees, of shippers' invoices and other documents necessary for clearance at Customs. Shippers are urged to use the ship's bag for their Customs documents whenever practicable, whether the bills of lading are ready or not. Failing this they should send the Customs documents by air mail, and so avoid the delay in the delivery of their cargo and the continued serious congestion. Bills of lading should be lodged as soon as possible in order that the ships' manifests may be completed promptly.

SUFFOLK POST MILLS.*

By REX WAILES, M.I.Mech.E.

(*Concluded from page* 445.)

TAIL wheels are mounted on the windshaft and drive stones situated in the tail of the buck. In appearance they are similar to brake wheels, but are smaller on account of the 5 deg. to 10 deg. inclination of the windshaft and the consequent smaller space available between the shaft and the stone floor. At Horham the cogs of the tail wheel faced forward, contrary to usual practice, probably to give room for a bolter in the tail. Not every mill has a tail wheel, but where these exist, wooden wheels of clasp-arm construction are the type most favoured. The largest are approximately 7 ft. in diameter and the smallest, 6 ft. Iron wheels are usually about 6 in. smaller. At Hartest, the 6 ft. wooden wheel (illustrated in Fig. 5, on the opposite page) has a new and larger rim bolted on and supported from the cants with ten cast-iron angle brackets. This views shows also the 18-in. diameter cylindrical wooden windshaft, and the bed for the lower millstone, which has been removed. At Stanningfield, an internal ring of cast-iron segments drove a flour-dressing machine. The iron wheels had tapered T-section arms; some having eight, as at Friston, and others four, as at Barley Green.

The wallower is the first driven wheel in the mill, and where both brake and tail wheels are used with an indirect drive from each, there is a wallower to each, as at Eye, Friston, Grundisburgh, Barley Green, Stradbroke, Swilland and Tunstall mills. The only wooden wallowers noted were at Westleton and Wickhambrook, the latter being solid; the rest were solid iron wheels with T or cross-section arms, usually eight in number, but sometimes four, five or six. When a direct drive to the stones is employed from the brake and tail wheels without intermediate gearing, the stone nut becomes the wallower. This arrangement is found in Drinkstone, Gedding, Halesworth, Hartest, Haughley, Horham, Thurston and Westhall mills; but the typical Suffolk mill has an indirect drive.

The "upright shaft," on which the wallower is mounted, is almost always of iron, the only exception noted being at Stanton, where it is of wood, 12 in. in diameter. Iron shafts are usually 4 in. in diameter, but vary from 5 in. at Laxfield to 3 in. at Parham; some are square or octagonal. The wallower is usually mounted on a square on the shaft.

In the case of an indirect drive to the stones, the "great spur wheel," as well as the wallower, is mounted on the upright shaft and drives the stones "overdrift" or "underdrift" through "stone nuts," as the spur pinions are called. "Overdrift" is the most common arrangement, and in this case the great spur wheel is usually mounted immediately below the wallower; though at Westleton it is mounted above the wallower and stayed to it at four points with wooden supports. When "underdrift," the great spur wheel is mounted on the bottom of the upright shaft, just below the stone floor. Iron wheels with cross, H, T and rectangular-section arms are used, Halesworth having the unusual number of seven. Woolpit is the only other mill to have a wooden great spur wheel, but there were half a dozen mortise wheels.

The stone nuts are mounted on the stone spindles, and are the last in the train of gears used to drive the stones. In the case of overdrift stones, they are mounted on shafts called "quants," and in the case of underdrift stones they are mounted on the "stone spindles," on which the top or "runner stones" are balanced. Haughley and Westhall mills have one wood nut apiece; the rest have solid iron or iron mortise wheels in approximately equal proportions. They have varying numbers of teeth, from 12 at Westhall, where the drive is direct from the brake and the tail wheels, to 28 at Barley Green, where the drive is through great spur wheels. Various methods are employed to throw these nuts out of gear so that the stones are no longer driven. In the case of overdrift stones, the cap of the top bearing is released and the quant is swung aside. In the case of underdrift stones, the nut is mounted on a taper on the stone spindle and is raised out of gear with the great spur wheel. Usually a rack and pinion operated by a handle is employed, but at Wrentham the nut was lifted manually, and held out of gear with an iron peg placed in a hole in the stone spindle. At Framsden, a "rigger" is used; this consists of two chains which are wound up on a horizontal spindle above the nut when this spindle is turned by means of a pulley and cord. The lower ends of the chain are fixed to the nut and lift it out of gear with the great spur wheel.

Most of the mills had two pairs of stones, but some had three pairs, namely, those at Darsham, Eye, Friston, Grundisburgh, Stanton, Barley Green, Stradbroke and Swilland. Of these, Stanton, and Swilland have but two remaining. All had gearing for three pairs of stones except Stanton, where the third pair in the tail took its power from the bolter drive through a pair of bevels. The majority of the stones are 4 ft. in diameter and over, only a few being 3 ft. 6 in. to 4 ft. in. diameter. Numbers are almost equally divided between those mills having stones in the breast only and those having them in the breast and tail, while a few have stones in the roundhouse driven by an engine. The majority of stones are overdrift, while those mills with three pairs had both overdrift and underdrift. The removal of stones from one mill to another is not uncommon; at Parham a French runnerstone came from the smock mill at Kettleburgh, while at Saxtead Green, a view of which is given in Fig. 6, opposite, a pair of French stones came from Monewden post mill. Removals such as these probably account for the fact that, at Peasenhall and Barley Green mills, there is a bulge on one side of the buck at the breast to accommodate stones larger than those for which the mill was built. Octagonal stone casings or ".vats" are almost universal, the only exception noted being the circular ones at St. Michael, South Elmham.

Only about half a dozen pairs of "peak stones" were noted, the rest being "French burrs"; but, at Drinkstone, a step in front of one of the roundhouse doors is part of a black "cullin" stone, about 4 ft. in diameter, dressed on both sides, one side being convex and the other flat. At this mill, too, the pair of stones in the breast has two "hoppers." At Westhall and Horham mills, the rear pair of stones has no hopper, the bin spout discharging directly into a somewhat elongated "shoe," as is commonly found in the north-west of England; while, at Syleham, the hopper for the rear pair of stones also resembles an elongated shoe. At Friston, the right-hand pair of stones in the breast has an inclined covered sieve under the bin spout and a funnel in the hopper. When the funnel empties it rises and opens a trap at the top of the sieve; the grain runs down, is sieved and fills the funnel, which shuts the trap until it is again emptied. This contrivance is known as the "balance dish."

The governors, or "lift tenters," regulate the gap between the stones, thus ensuring even grinding whatever the speed of the mill. In some cases, the stone spindle rests on a wooden bridge tree, sometimes curved, which is moved up and down at one end in a mortise; in others, the spindle is supported on a cast-iron bridge tree below the normal spindle support; in others, again, the tentering gear is completely of iron. There are three principal methods of driving the governors. The most usual is by belt from the stone spindle; the next is by belt from the upright shaft; and, at Friston, Parham, Swilland and Worlingworth mills, the governors are mounted on the stone spindle. At Wickhambrook, one pair was driven by belt from a quant. At Peasenhall and Saxtead mills only, there are two pairs of stones regulated by one pair of governors.

Each pair of stones is usually provided with a "bell alarm," to warn the miller when the hoppers are running short of grain. These depend on the weight of the grain in the hopper keeping a string taut and holding a lever on the bell itself away from some moving part of the machinery which, if contact is made, will ring the bell as it turns. Many are the devices rigged from string and wood by which this end is attained; but they can in the main be reduced to a few basic methods. The most common (as in Fig. 6, opposite) is to allow a lever to fall or rise against some portion of the wallower or cams attached to its arms. Alternatively, the bell or lever may touch some portion of the brake-wheel cogs, bolts, or cams on the inside face of the rim. A similar method is to utilise the back of the tail wheel in the same way; or the bell itself can fall against the "damsel," the device which vibrates the shoe in the case of underdrift stones. At Drinkstone, the bells drop on to the stone nuts at both head and tail, while at Horham a lever fell and touched a pin driven into the edge of the wooden pulley driving the governor of the pair of stones in question.

As grain is fed to the stones from the bins above, it is necessary to hoist it up to the top of the mill in order to fill them, and this is effected by a "sack hoist." The hoist itself usually consists of a horizontal wooden drum, about 12 in. in diameter, located in the roof ridge and sometimes covered with sacking or iron strips. Attached to it is a chain long enough to reach through the mill to the ground, and at one end of the drum is a driving pulley and a bearing resting on a hinged sole piece. Normally the belt passing over the pulley is slack, but by pulling a cord, known as the "sack cord," which extends down through the mill, the hinged sole piece is raised and if the mill is running the tensioned belt takes up the drive, rotates the drum and the "sack chain" is wound up. When the sack cord is released, the drive ceases and the chain will unwind until it or its load comes to rest on the floor. As it is not usually convenient to have the sack chain and sack cord in the centre of the mill, pulleys are located to bring them to convenient points for operation, while the sack cord is provided with a multiplying

* Paper read before the Newcomen Society, in London, on Wednesday, November 12, 1941. Abridged.

SUFFOLK POST MILLS.

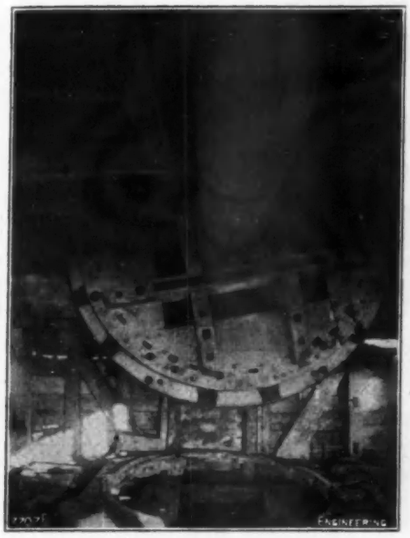


FIG. 5. 6-FT. TAIL WHEEL AT HARTEST.

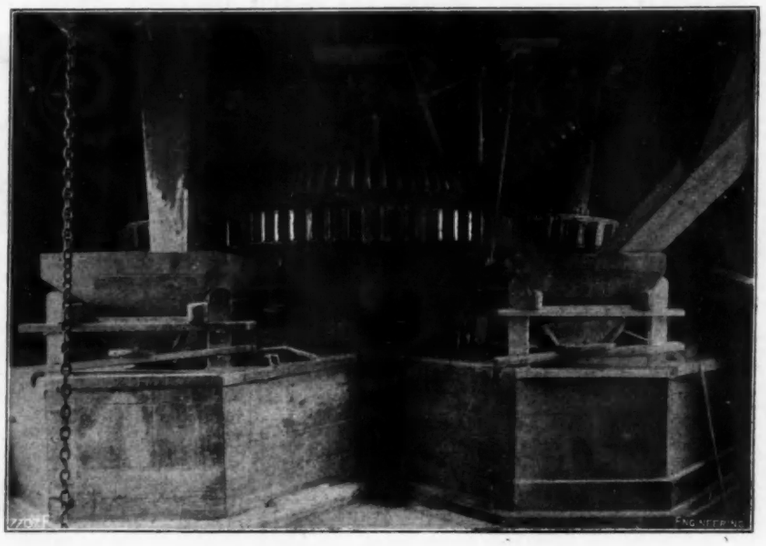


FIG. 6. INTERIOR OF SAXTEAD GREEN MILL.

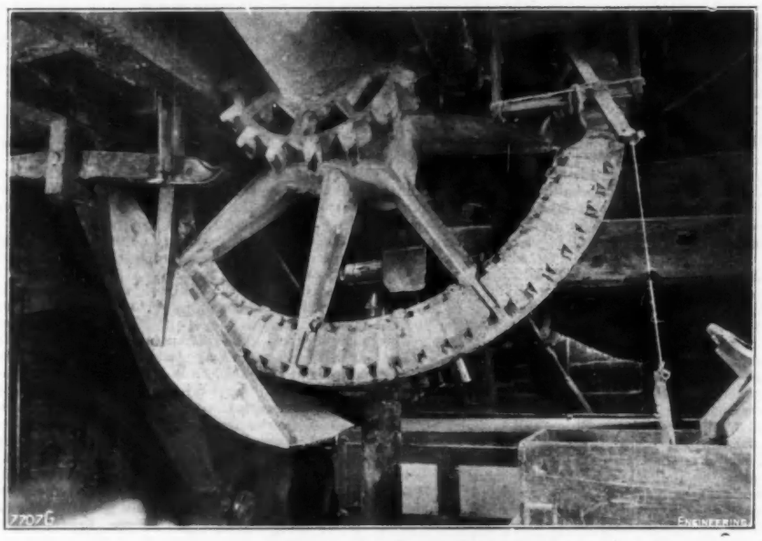


FIG. 7. JUMPER AND DRIVING GEAR AT FRISTON.

gear for greater ease of operation. The most usual form of drive to the drum is by belt, from a pulley mounted on the windshaft in front of the brake wheel. Drinkstone and Stanton mills have chains instead of belts, and several mills have pulleys behind the brake wheel. At St. Michael South Elmham, the belt is behind the tail wheel, and Westhall has a 17-tooth mortise spur gear driven from the inside of the brake-wheel cogs.

The most usual accessory is a flour-dressing machine, either a "bolter," which used a revolving wooden frame covered with a seamless woollen bolting cloth, through which the flour was beaten; or the more modern "wire machine," having a stationary wooden cylinder panelled in wire mesh, through which the flour was brushed by brushes fixed to a central revolving spindle. Most, if not all of these, have been disused since the Flour Restrictions Act of 1916. Friston and Parham mills have modern "centrifugal dressers" in the tail. Saxtead has one with an oat crusher and stones in the roundhouse, driven by an oil-engine. Modern oat crushers, when placed in the buck, are usually in the tail; Friston and Horley mills have "jumpers" or "donkey sieves" in the tail. Fig. 7, above, shows the jumper and its drive at Friston. The wedged cogs in the tailwheel are noteworthy. The centrifugal flour-dressing machine and the oat crusher are in the background. The most usual method of driving these machines was by a wood or iron skew gear from the brake wheel. At Eye, Friston and Grundisburgh mills, an inner ring of cogs on the brake wheel was provided for this drive, and at Stanningfield and Stanton mills an internal gear of iron segments is used on the tail and brake wheels, respectively. Haughley has a jumper driven from iron cogs in the form of strips, coach-screwed on to the windshaft behind the tail wheel. At Friston, the jumper is driven by a strap and iron-shod lever from an iron skew-gear bolted on to the windshaft in front of the tail wheel. At Syleham, the dresser in the right-hand side of the tail is driven by skew gear from the top side face of the tail wheel, down by a vertical shaft and then by a horizontal belt, which lies under the porch outside the mill. Wickhambrook had a bolter across the tail, driven by an upturned mortise bevel wheel on top of the upright shaft and above the "sprattle beam," which carries the top bearing of that shaft.

Thorpeness mill was altered to drive a double-acting pump through a 30-tooth iron bevel below the wallower. This drives a 48-tooth mortise bevel on a horizontal shaft, which, in turn, drives a disc crank and a 1¼-in. diameter pump rod, passing down a 2-in. diameter hole bored right through the post of the mill. The well is 46 ft. deep, and the delivery of water is 1,800 gallons per hour. An electric motor in the round-house drives a separate pump when required. In addition to separate power-actuated mills, a number of post mills have stones and machinery located in the roundhouse and driven usually by an oil engine. Thornham Magna and Wenhaston mills have portable steam engines. At Wickhambrook, in addition to a pair of engine-driven stones in the roundhouse, there is a drive by belt up into the buck to fast and loose pulleys on the first floor. An iron bevel pinion on this countershaft drove a wheel on the upright shaft of the wind drive. There was also a sack hoist driven from this countershaft, by belt back to a shaft in the ceiling of the first floor.

The earliest mention of a windmill in Suffolk is contained in the *Chronicle of Jocelyn de Brakelond*, which is quoted in Bennett and Elton's *History of Corn Milling*. This reference is to a windmill erected by Dean Herbert on his glebe lands at Haberdon in 1191. In a pamphlet, *The Poleys of Broxstead*, mention is made that, in 1256, two mills, one a water mill, existed at Hartest. There is, however, no proof that the other was a windmill. Three mills bore Seventeenth-Century dates: Drinkstone 1689, Snape 1668, and Stradbroke 1688. Thurston mill, moved from Pakenham in the Eighteenth Century, stands on a mill site marked on a map of 1689. Of the Nineteenth Century mills, Darsham was moved on July 6, 1801, from Mill Hill, about 1¼ miles away. Gedding mill was moved twice, the second time in 1867, as previously mentioned. It stuck in a water splash *en route* and had to be left in it overnight. Pettaugh mill was built in 1865 on the site of an earlier mill by Collins of Melton, and Thorpeness mill was built at Aldringham in 1803 and moved in 1924.

Millwrights and millers notes made in the mill are often of considerable interest, and at Haughley they are more than ordinarily so. On a roof timber was:—"Harry Sore Haughley aged 18 in February 1884 at this time of the year 1884 there was an earthquake when Harry Baker was miller and Harry Sore carter and it stopped the mill which Harry Sore was clothing £10,000 damage was done in England." This was the famous Colchester earthquake.

The last miller at Haughley, Mr. S. Goode, told the author that, when he was a boy, an old man in the village had told him that, when he himself was a boy, he had seen the mill built, and that soldiers on their way to the coast to embark for the Peninsular War had manned the ropes when the post was being erected.

TIME LIMITS FOR NON-DELIVERY OF GOODS BY RAILWAYS.—The Ministry of War Transport has agreed, as a war-time measure, to extend the time limit for the advice of the non-delivery of goods by the railways from 21 days to 28 days. Similarly the period, during which claims must be made, has been extended from 28 days to 42 days.

"BRISTOL" HERCULES III AERO ENGINE.

MESSRS. THE BRISTOL AEROPLANE COMPANY, LIMITED, BRISTOL.

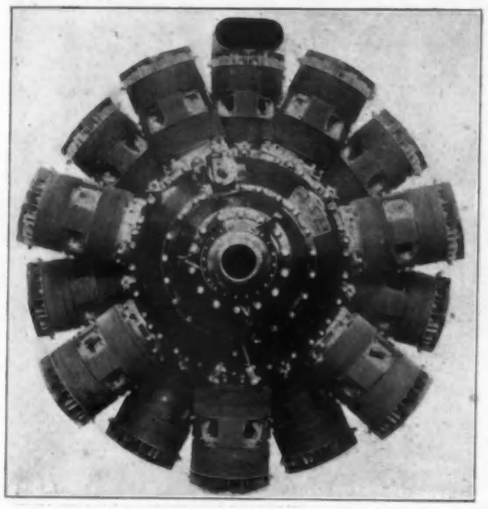


FIG. 1. FRONT VIEW OF ENGINE.

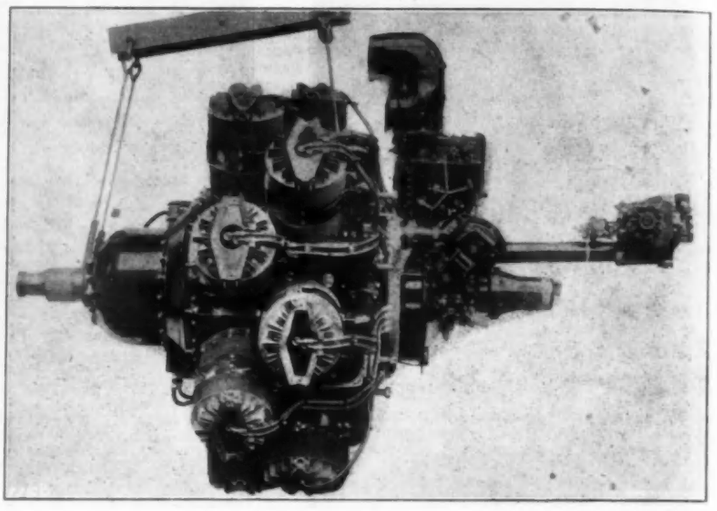


FIG. 2. SIDE VIEW OF ENGINE AND ACCESSORY GEARBOX.

THE "BRISTOL" HERCULES III AERO ENGINE.

IN our account of the "Beaufighter" long-range fighting aeroplane on page 116, *ante*, a brief reference was made to the two "Bristol" Hercules III engines by which the machine is fitted. By the courtesy of Messrs. The Bristol Aeroplane Company, Limited, Filton, Bristol, we are now able to supplement this reference by a more detailed description and to illustrate the engine in Figs. 1 to 8 on this and the opposite pages, and on page 470. The Hercules III engines are of the radial type with 14 air-cooled sleeve-valve cylinders arranged in two planes and staggered as will be evident from Figs. 1 and 2. There is a two-speed supercharger which gives considerable flexibility of performance. Thus, each engine develops 1,400 brake horse-power for take off, and for climbing 1,170 brake horse-power at 2,500 ft. with low-speed supercharging and 1,090 brake horse-power at 14,500 ft. with high-speed supercharging. For level flight the maximum power at 1,500 ft. is 1,425 brake horse-power with low-speed supercharging and 1,270 brake horse-power at 15,000 ft. with high speed supercharging. It was stated in the account of the aeroplane referred to above that constant speed airscrews were fitted, and these propellers are of the controllable-pitch type. The airscrew reduction gear ratio is 0·44 to 1·0. The reduction gear is of the bevel epicyclic type. The cylinder bore is 5·75 in. (146 mm.) and the stroke is 6·5 in. (165 mm.) the cubic capacity being 2,360 cub. in. (38·7 litres). The overall diameter is 4 ft. 4 in., and the weight 1,850 lb.

The construction of the engine is perhaps not apparent from the front and side views given, respectively, in Figs. 1 and 2, but those of the crankcase, Fig. 3, and of the crankshaft and connecting rods, Fig. 4, are more informative. It will be seen from Fig. 3 that the crankcase consists of three main parts and a cover at the forward end. The three parts are machined from aluminium-alloy forgings, the joints between them lying in the plane of the cylinder axes. One of the coupling bolts can be distinguished to the left of Fig. 2. The centre section of the crankcase is shown in greater detail in Fig. 4 mounted on an assembly jig. It will be apparent from both Fig. 3 and Fig. 4 that the openings for the cylinders on the crankcase periphery are not circular but one half is, roughly speaking, elliptical, this contour being necessary to accommodate the sleeve-valve gear. The cylinders are each attached to the crankcase by 12 studs, and are spigoted into the holes, the depth of the spigot being seen in Fig. 5, page 470. From this view it will be seen that the cooling fins are thin, deep and closely-pitched. They are machined in the aluminium-alloy forging forming the cylinder barrel. The fins at the centre of the cylinder are interrupted by the inlet and exhaust openings. The cylinder head, seen on the left of Fig. 5, is of cast Y-alloy, spigoted deeply into the cylinder bore and provided with obturator rings. The head is well provided with radial cooling fins, the circumferential fin giving a deceptive appearance of thinness to the flange.

The sleeve valve is seen on the right of Fig. 5. It is made of a special alloy steel and is ported at the top as shown. It is bracketed out at the bottom to take the universal spherical bearing for the actuating crank, this bearing being shown detached in the figure. Several of the actuating cranks are visible in Fig. 4, lying in conical recesses in the side of the crankcase. It can be seen in this illustration that the shafts are mounted in ball bearings and carry pinions on the inner ends which are driven through a system of spur gears from the engine crankshaft. It will be appreciated that, as the inlet and exhaust ports are at the same longitudinal position on the cylinder barrel, as shown in Fig. 5, the sleeve must be given a partial rotation during its vertical stroke in order to provide the necessary cyclic opening and closing. This rotation is effected by the actuating cranks, the full stroke of which is utilised for the up and down motion, but, since the driving point of the crankpin is radially farther from the centre of rotation than is the contact face of the sleeve with the piston, the rotational oscillation of that face is less than the crankpin stroke. The movement of any point on the sleeve is thus elliptical, the vertical motion being approximately half as much again as the horizontal movement. The spherical bearing is a great improvement on the original connection and operates entirely satisfactorily.

A piston is shown in Fig. 6. It is machined from an aluminium-alloy drop stamping and has a flat crown. Three packing rings are fitted above the gudgeon and, normally, two scraper rings, though the particular piston illustrated has only one scraper ring. The gudgeon pin is of the floating type with end locking rings. The connecting rod assembly, seen in Fig. 4, needs, perhaps, an explanatory comment in that the gudgeon pin ends are apparently not free, being attached to brackets on the crankcase. These brackets are, of course, only a temporary checking device. The connecting rod assembly consists of one master rod with a "big-end" to which the other six rods are articulated. The master rod is subjected to bending stresses from the other six rods, hence its heavier section. All seven rods are of H cross-section and are machined from nickel-chrome steel stampings. The master rod is coupled to the crank pin as shown in Fig. 4. The crank web seen in this view is balanced. The crankshaft is of alloy steel and is built up in accordance with standard Bristol practice. The end of the shaft visible on the left takes a splined shaft for driving the supercharger. The crankshaft is mounted in three main roller bearings.

The two-speed supercharger unit is mounted at the rear of the crankcase, with the carburettor on the top of the volute casing, the position of the carburettor being identified in Fig. 2 by the inlet cowl pointing forward above the cylinders and also visible in Fig. 1. The drive from the splined shaft mentioned above operates the supercharger through hydraulically-actuated clutches. The supercharger is of the gear-driven centrifugal type which was first put into quantity production by the Bristol Company and has since been generally adopted. The impeller is of aluminium alloy and is of the double-shrouded type. When operating in the high-speed gear it runs at over 20,000 r.p.m. The carburettor is of the down-draught type incorporating automatic boost and mixture controls. The air ducts are visible in Fig. 2 and embrace the cylinders over the inlet ports, as is clearly seen on the two centre cylinders of the rear row. It can be readily seen in this figure there are two ignition plugs to each cylinder, there being two independent magnetos so that continued running is assured should one become inoperative. The ignition leads are carried in the special screened harness, readily recognisable in Fig. 2, in order to eliminate interference with radio apparatus. The magnetos, as well as the oil and petrol pumps and some other accessories, are mounted on a cover attached to the rear of the supercharger unit.

The apparatus seen to the right of Fig. 2 is an accessory gearbox which, it is obvious, is attached to the supercharger unit casing and is driven from the supercharger drive. The gearbox has provision for attaching six accessories, such as electric generators; hydraulic pumps for operating the jacks and rams of undercarriages, wing flaps and gun turrets; vacuum pumps for actuating certain instruments; and air compressors. These auxiliaries are more conveniently accessible when situated as shown and not on the supercharger casing, and installation is considerably simplified. For example, the leads and pipes to the body of the aircraft are shortened and the engine can be removed as a whole without disturbing them. This gearbox was one of the pioneer developments of the Bristol Company. The engine is pressure-lubricated, the normal working pressure being 80 lb. per square inch. When starting, this pressure is increased to 200 lb. per square inch, so that the engine can be opened up to full take-off speed immediately and without detriment. As soon as the engine is warmed up, the oil pressure automatically returns to the normal. The installation of the engine in the aeroplane does not call for comment here, as it is sufficiently indicated in the previous article referred to earlier, but it may be recalled that the engine is fitted with a long-chord cowling, the trailing edge having controllable gills to govern the cooling-air flow and the leading edge carrying the exhaust collector. In this latter connection, attention may be drawn to the radiating exhaust pipes on the cylinders of some of the engines seen on an assembly line in Fig. 7, page 470. These pipes, which have square flanges, are bolted to the exhaust ports, the flange seatings being clearly visible in Fig. 5.

The photograph reproduced in Fig. 7 was not taken at the Bristol works, but at a new factory in the North. This factory was built up with a nucleus staff of less than 50 persons from the parent Bristol Company, while the machinery is wholly new, as also are the methods employed; yet a very large output is obtained from comparatively unskilled labour. A high proportion of female labour is employed. It is claimed by Messrs. The Bristol Aeroplane Company that the main contributory factor to both the quantity and quality of the output is the simplicity and robustness

"BRISTOL" HERCULES III AERO ENGINE.

MESSRS. THE BRISTOL AEROPLANE COMPANY, LIMITED, BRISTOL.

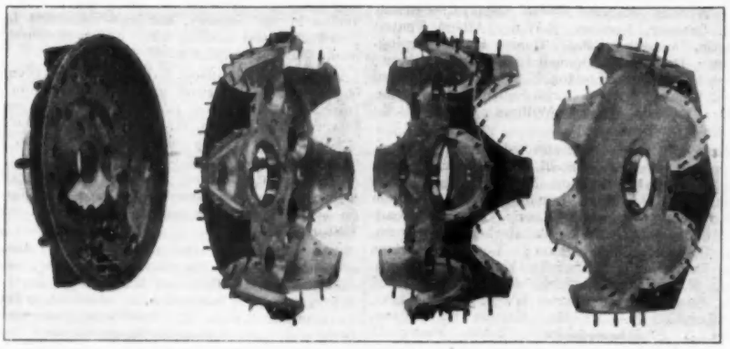


FIG. 3. CRANKCASE AND COVER.

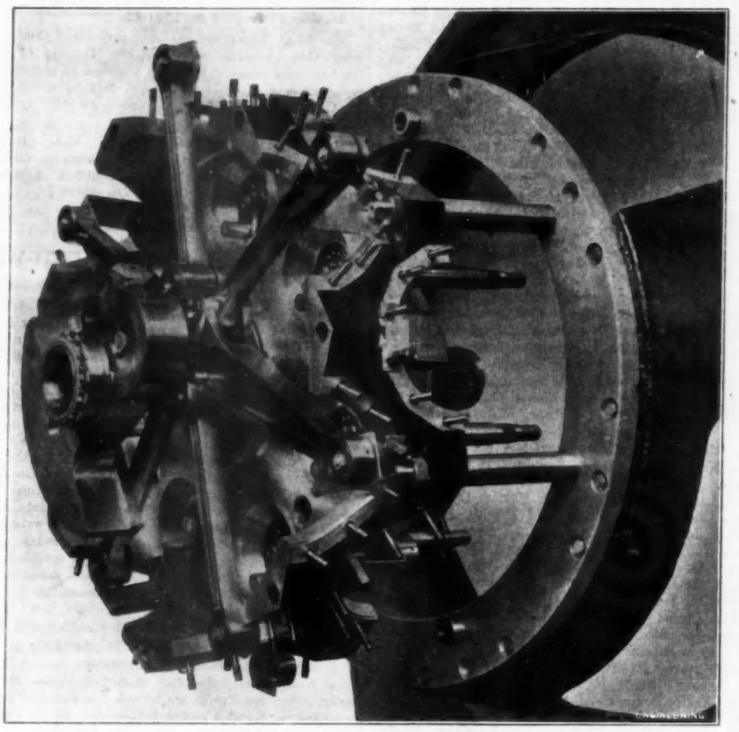


FIG. 4. CRANKSHAFT AND CONNECTING-ROD ASSEMBLY.

of the sleeve-valve engine. Certainly, when the parts required for a single sleeve-valve cylinder are compared with those necessary for a cylinder with poppet valves, this claim seems to be justified. From the point of view of maintenance, again, the sleeve-valve engine does not call for the same amount of adjustment, since there is no external valve-operating mechanism.

Fig. 8, on page 470, shows an engine in one of the Bristol test rooms. It will be recognised, from the ignition leads and twin magnetos visible in the figure, that it is the rear of the engine that is there seen, the front part being hidden in a wind tunnel the flow through which simulates that passing over the engine from front to rear as is the case when the engine is mounted in the aeroplane. The fan producing the air flow and its 500-h.p. driving motor, are situated behind the partition seen in the left background, as is also the Heenan and Froude dynamometer, which is connected to the propeller shaft. A 100-h.p. motor is also provided to start the engine and turn it as required when a dynamometer test is not being carried out. The engine is mounted on a wheeled table, as shown, so that it can be readily run into position. It will be obvious that, as the air stream laden with exhaust gases blows into the test room, the room cannot be occupied. The testing staff accordingly works in a control room adjacent to the test room and can see the engine through the window visible on the right. This window is provided with three walls of glass with intervening air spaces in order to deaden the noise of the engine. The walls of the test room are covered with sound-insulating material. The cooling air and exhaust gases escape from the test room through a tunnel in line with the test bed, not visible in the figure.

In conclusion, it may be noted that the Hercules engine, in addition to being used in the twin-engined Bristol Beaufighter, is employed in the four-engined Short Stirling bomber. The Hercules engine is also used in large flying boats and is being fitted to several other of our newer two-engined and four-engined heavy bombers.

CONTROL OF BICHROMATES.—The Minister of Supply has issued the Control of Bichromates (No. 1) Order, 1941 (S.R. & O., 1941, No. 1818, price 1*d.*), controlling the prices of commercial-grade sodium and potassium bichromates in quantities of less than 1 cwt.

"THRESHOLD" TREATMENT FOR SCALE PREVENTION.

THE short account of what was then a new treatment for the prevention of scale in low-temperature installations, such as condensers, heat exchangers and other cooling systems, given in ENGINEERING, vol. 147, page 293 (1939), may now be supplemented by some further particulars obtained by experience of the treatment in a number of power stations and works throughout the country, these particulars being based on some notes issued by Messrs. Keith Piercy, Limited, whose present address is Park Hall, Kidderminster, Worcester. To avoid repeating the previous account, it may be stated briefly that the process consists in the application of low concentrations of sodium hexametaphosphate, the trade name of which is "Calgon," in water, the amount of Calgon required being usually of the order of 2 lb. per 100,000 gallons of water. This treatment, known as "Threshold Treatment," it is important to observe, is entirely distinct from other applications of Calgon in the treatment of water, such applications being to boiler feed water, to certain detergent operations, etc.

The phenomenon of scale deposition is most often associated with steam boilers in which high temperatures exist and there is a tendency to overlook the fact that the deposition of calcium carbonate from most natural waters can occur at a comparatively low temperature. The resultant scale, when formed, as it frequently is, in condensers, heat exchangers and the like, insulates the cooling surface and reduces the rate of heat transmission from the water to be cooled to that provided for cooling. This condition may often be more important than at first sight appears; for example, it may result in a loss of vacuum in power station condensers. The threshold treatment not only prevents such scale formation, but will often slowly remove old formations of a calcium carbonate deposit. This characteristic is, of course, of importance only when starting the treatment on an old plant, since pieces of scale may become dislodged and prove inconvenient. It has been found, however, that stoppages of pipe lines from this cause are infrequent, while a converse effect may be noticed; for instance, valves which could not previously be closed are freed by the removal of the old scale.

The limiting conditions for successful threshold treatment are two-fold: In the first place, the temperature of the water to be treated should not exceed 185 deg. F. (85 deg. C.). Moreover, should the main body of the water be not so hot as this, only partial success is likely to be attained when there is a high surface temperature, as in the cooling of furnace parts. Further, the feed water for evaporators, even when these work at a temperature lower than 185 deg. F., is not suitable for threshold treatment, but is more properly treated by the application of Calgon to the boiler feed water. The other limitation concerns the original hardness of the water due to the presence of calcium bicarbonate, this substance, together with the corresponding magnesium salt, resulting in the so-called temporary hardness. It is not easy to state a precise limit, since the time of contact and a fairly high temperature have some influence. Thus, in one set of laboratory tests threshold-treated water was kept for an hour at 104 deg. F. (40 deg. C.) without deposition when the calcium bicarbonate concentration was as much as 80 parts of $CaCO_3$ per 100,000, but at 176 deg. F. (80 deg. C.) the limiting concentration for no deposition was about 30 parts of $CaCO_3$ per 100,000. It is rare, however, to find calcium bicarbonate concentrations higher, in natural waters, than the latter figure, and times of contact of one hour are not common. It may be noted that even if all deposition is not prevented, the amount deposited is always far less than when no Calgon is used. When the cooling water is circulated through a tower or sprays after passing through the plant and is then returned to circuit, it should contain about two parts of Calgon per 1,000,000 parts of water, a condition attained by using make-up water containing about 5 lb. of Calgon per 100,000 gallons. In addition, the concentration of calcium bicarbonate must usually be controlled by systematic blow-down. It is recommended, generally, that the temporary hardness due to calcium bicarbonate should not be allowed to exceed a value of from 25 parts to 35 parts of $CaCO_3$ per 100,000.

Waters which have been softened in the cold by the addition of lime or lime-soda are sometimes found to deposit calcium carbonate gradually in long mains. This can be easily and cheaply prevented by the addition of Calgon at the rate of 0·5 lb. per 100,000 gallons. As most applications of this kind are in municipal supplies, it is necessary that Calgon should not be deleterious to animal life, a fact which has been established by exhaustive experiments in the United States and in this country. When threshold treatment was first developed the possibility that it would reduce the corrosion of mains carrying soft water was not anticipated, but it is now established that concentrations of Calgon varying from 0·5 lb. to 5 lb. per 100,000

gallons will appreciably diminish the corrosion by waters of low *p*H value. There is the additional advantage that Calgon will prevent the appearance of an iron deposit in water containing soluble iron, as some well waters do, if it is added before the atmospheric oxygen has converted the ferrous iron into the ferric state.

It is advisable to add the Calgon continuously to the water in the form of a solution, but no elaborate proportioning apparatus is necessary. Calgon is supplied in thin glass-like plates, soluble in water. These are placed in a basket of steel, stainless steel, or Monel-metal gauze suspended just below the water surface. After the plates have dissolved the solution should be stirred and then made alkaline to phenolphthalein by the addition of soda ash or caustic soda. Control of the drip feed of the solution to the water is usually sufficiently close if a needle valve is inserted in the pipe, and a sight glass may be fitted to help operatives to regulate the flow more easily. All the feeding equipment should be made of one of the metals mentioned above as being used for the basket.

ZINC OXIDE IN MACHINE LUBRICATION.

SINCE the employment of zinc oxide, a commonly-used white pigment, in machine lubrication would seem to be anomalous, even when applied with grease or lubricating oil, this short account may be prefaced by the statement that it has undoubtedly proved effective in a number of abnormal and exacting conditions. For other conditions, on the other hand, it is entirely unsuitable, and its use for such duties as cylinder lubrication, or where wick or felt-pad application is employed, is impracticable, is not for a moment advanced. The practice, originating in the United States, is being extended to Great Britain and the Dominions by Messrs. Alexander Duckham and Company, Limited, whose temporary address is Woodlawn, Page Heath-lane, Bickley, Kent. It must be admitted that in some instances the precise manner in which the zinc oxide functions is obscure, but it has been established that a thin film of zinc, of the order of 0·0004 mm. in thickness, forms on the bearing surfaces and when these are ferrous, this film inhibits corrosion. Apparently, also, the film fills up the minute hollows which always exist on a machined surface, even when finely finished, and so forms smooth working face and one which, moreover, is capable of withstanding high local temperatures and pressures. Again, it is held that the oxide, which is in an extremely fine state of subdivision, so that with its vehicle it is almost colloidal, retains molecules of oil, and so prevents the rubbing surfaces from seizing even when, apparently, all the lubricant has been forced out.

In this latter connection, the results of some tests carried out at the Pittsburg Testing Laboratory may be mentioned. The parts in contact had a rubbing speed of 540 ft. per minute and a load of 8,000 lb. per square inch. The tests were made with ordinary grease and zinc-oxide grease, respectively. At the start wear with the oxide grease was rapid, 0·004 in. being removed in the first half hour, but at this point wear ceased and the test was run for 12 hours without any more occurring. With the ordinary grease, wear took place more slowly and it took 5·5 hours to remove 0·004 in. The significant point, however, is that the wear continued until it was 0·007 in., at which point, namely, 11 hours from the start, the parts seized. The temperature curves were of the same character as the wear curves. With the oxide grease a drop from 200 deg. F. to 125 deg. F. took place in the first hour, the temperature rising to about 140 deg. F. later, and remaining constant throughout the remainder of the test. With ordinary grease the temperature fell slowly from 220 deg. F. to 160 deg. F. near the end of the test, a sharp rise to the original temperature occurring just before seizure.

Some results from actual extended applications of oxide oils and greases may be noted. In the lubrication of motor-car and lorry gears of all types, there was reduction in noise, wear, temperature, and consumption, while with plain spur gears, in laundries, dairies, etc., where there is corrosion, pitting and rapid wear, these troubles were reduced to negligible proportions. Successful results have been obtained with ball, roller and plain bearings in industrial plants, the advantages being more marked in situations where fumes, corrosive solutions, steam, water, weathering and high temperature are encountered. For certain applications, such as chain and conveyor systems, and in the links of crawler tracks, it is claimed that the zinc-oxide lubricant has proved very effective, as also in various types of clutch and expanding brakes. In pressing, drawing and spinning, the lubricant has increased tool life and efficiency, and reduced scoring and scratching. The lubricant is made with oil or grease for particular requirements, but the selection requires considerable care.

INSTITUTION ELECTIONS.

INSTITUTION OF ELECTRICAL ENGINEERS.

Associate to Associate Member.—Albert Stanley Clarke, London, N.18; Percy Bruce Campbell, St. Albans; Christopher Edmund Downie, Hebburn-on-Tyne; William Robert Dowse, Malaya; Ernest William Greener, London, N.W.6; Albert Fenton Hardcastle, Doncaster; Percy George Hobbs, Orpington, Kent; Duncan MacDonnell Jannaway, Chatham; Frederick Henry Long, London, N.21; Harold Howard Longson, Bickley, Kent; Bertie Smith, King's Lynn, Norfolk; Captain Henry William White, R.E., Newcastle-upon-Tyne.

Graduate to Associate Member.—Frederick Akister, Northampton; James Almond, Farnworth, Lancs.; George Albert Baker, London, N.17; Bernard Caress Bartholomew, B.Sc. (Eng.), London, S.W.15; William Arthur Bocock, Coventry; Maurice Edward Broadbent, Huddersfield; Frederick Herbert S. Brown, Sutton Coldfield, Birmingham; Louis Robertson Brown, Dunfermline; Prafulla Kumar Chatterjea, London, N.5; Donald Clark, B.Sc. (Eng.), East Horsley, Surrey; Alan Charles W. V. Clarke, B.Sc., Ph.D., London, N.W.2; Rex Gordon H. Clutton, Helensburgh, Dumbartonshire; Charles Henry C. Cooke, Southport; George Frazer Cooke, Esher, Surrey; James Richard Cox, Liverpool; Cyril Austin Cross, Oldham; Archibald John Eales, B.Sc. (Eng.), Wolverhampton; Lieut. Henry Leonard Euler, R.N.V.R., London; Harry Foden, Barking, Essex; George David Foster, Birstall, Leeds; Donald Henry Gale, Exeter; Gerald Philip Goodman, Walsall, Staffs.; Leonard Owen Gosling, B.A., Bromley, Kent; John Gray, Malaya; Edward John Grout, Epsom, Surrey; Bhisham Ji Gulati, M.Sc., Lahore, India; Dhundiraj Narayan Halbe, B.Eng., B.Sc. (Eng.), Poona, India; Richard Christian Hawkes, B.Sc. (Eng.), Haslemere, Surrey; Elec. Lieut. James Joseph Haywood, R.N.V.R., London; Robert Hiam, Birmingham; George Herman Hickling, B.Sc., Newcastle-upon-Tyne; John Henry R. Hill, London, N.W.9; Frank Holmes, B.Sc., Keighley; Clifford Morton Holt, Bradford; Arthur Hopkinson, Rochdale; Raymond Ernest Hughes, Stanmore, Middx.; Eric Hunt, Birmingham; Cyril Rees Jephcott, Droitwich; Jonas Geoffrey Jessel, London, N.14; Henry Kerr, M.Sc., Lurgan, Co. Armagh; Andrew McLeod G. Korn, Renfrew; Harry Ernest Laflin, Wolverhampton; Peder William Larsen, B.Sc. (Eng.), London, N.11; Elec. Lieut. Cyril Frederick Locke, R.N.V.R., Richmond, Surrey; George Richard Lunt, Newcastle-upon-Tyne; George Daniel Lynch, London, S.E.8; Rowland William McOwen, Ilford, Essex; Thomas Frederick Mason, Sutton, Surrey; Lt.-Col. William Harvey Mather, R.A., Guisborough, Yorks.; Albert Dent Matthews, Portsmouth; Sub-Lieut. Richard Boyle Maurice, R.N.V.R., Portsmouth; James Noel Mercer, B.Sc., London, W.6; Frederick William Miller, Bath; Frederick John Miranda, Birmingham; William Stephen Morris, Little Sutton, Wirral, Cheshire; Leslie Arnold Moxon, B.Sc., Liss, Hants.; John Stewart Neal, M.A., South Walsham, Norfolk; John Paragiotis Neocosmos, Cardiff; Lieut. James Eastwood Noble, R.A.O.C., Pembroke Dock; Richard Arthur E. Osborn, Northampton; Albert Edward B. Perrigo, B.Sc. (Eng.), Havant, Hants.; William James Phillips, Preston; Richard Stanley Pikering, Lichfield; William Eric Redmayne, London, N.3; James Ritchie, B.Sc., Peterhead, Aberdeenshire; Norman Charles Rolfe, B.Sc. (Eng.), Ilminster, Somerset; Arthur Roger Rye, Virginia Water, Surrey; Edwin Charles R. Scarfe, B.Sc. (Eng.), Dartford Heath, Kent; Rajani Kumar Sen, B.Sc., Manbhum, India; Henry John Sheppard, B.Sc., Wednesfield, Staffs.; Bernard Arthur Shipstone, Chelmsford, Essex; Samuel Silcock, Manchester; Stanley Slingsby, Birmingham; Lieut. William Alexander Slorick, B.Sc. (Eng.), R.E., Bath; Charles Eric Smith, B.Sc. (Eng.), Sheffield; Sub-Lieut. Harry Redvers Smith, R.N.V.R., Llandudno, N. Wales; Charles Robert G. Straughen, Birmingham; William Henry Turnbull, South Shields; James William Walker, B.Sc. (Eng.), Manchester; Arthur Muir Watt, Johannesburg, S. Africa; Captain Reginald Frederic A. Weaire, Enfield, Middx.; Arthur Wilson, B.Sc. (Eng.), Blackburn; John Charles Wilson, Greenford, Middx.; Harald Isbister Wood, B.Sc., Altrincham, Cheshire; Herbert Thomas Wormell, B.Sc. (Eng.), London, S.E.18; Thomas Stanley Wylie, Manchester.

LOANS TO LOCAL AUTHORITIES FOR ENGINEERING WORKS.—The Ministry of Health informs us that, during the quarter ended September 30, loans sanctioned to local authorities in England and Wales amount, in the aggregate, to 155,096*l.* for water-supply works; to 69,342*l.* for schemes for the disposal of waste products, including sewerage, sewage-disposal and refuse-destruction works; to 312,573*l.* for air-raid precautions schemes, and to 123,684*l.* for road and bridge works.

PERSONAL.

BRIGADIER-GENERAL SIR OSBORNE MANCE, K.B.E., has accepted temporarily the appointment (unpaid) of Director of Canals in the Ministry of War Transport.

PROFESSOR G. B. WATERHOUSE, Ph.D., D.Met., of the Massachusetts Institute of Technology, who is well known in this country, has been appointed technical consultant, steel section, Office of Production Management, Washington, U.S.A.

SIR ALFRED ROBINSON, K.B.E., C.B., has been elected chairman of the Bristol and District Section of the Institute of Transport, in succession to MAJOR F. J. CHAPPLE, D.S.O. MR. H. J. S. YOUNG, of the Port of Bristol Authority, has succeeded the late MR. E. LEE as honorary secretary of the Section.

MR. T. W. LIPPERT, who has been metallurgical Editor of our contemporary, *The Iron Age*, New York, for several years, has now been appointed managing Editor.

MR. ROGER DUNCALFE, President of the Association of British Chemical Manufacturers, has been appointed chairman of the Chemical Divisional Council of the British Standards Institution, in succession to DR. E. F. ARMSTRONG, F.R.S., who has been chairman of the Divisional Council since its formation some ten years ago. Dr. Armstrong is now fully occupied as chemical adviser to the Ministry of Home Security.

SIR ERNEST G. G. GRAHAM-LITTLE, M.P., has been re-elected chairman of the Council for External Students of London University for 1941-42.

MR. R. O. HERFORD has been appointed Controller of Inspection (Administration) in the Ministry of Supply. He has been released from his position as general works manager and director of Messrs. Renold and Coventry Chain Company, Limited, Coventry, to take up his new duties.

MR. E. BRUCE BALL, JUN., M.A. (Cantab.), M.I.Mech.E., has been made joint managing director of Messrs. Glenfield and Kennedy, Limited, Kilmarnock. The appointment took effect on December 1.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Operations on the steam-coal market were sustained at a good level during the past week. There was a brisk home demand but, in view of the heavily committed nature of most producers, the amount of new business that could be handled for early delivery was again strictly limited. As a rule collieries are giving preference to the vital war industries and the public-utility undertakings and some customers are complaining that deliveries under their contracts are in arrears. Export business is quiet, owing to the official restrictions, in spite of a steady demand from the markets still open to Welsh coals. The general tone of the market remains very firm. Best large coals are still being steadily absorbed by deliveries under existing contracts and the demand for the sized grades was still active, last week, and could not be fully satisfied, especially for early delivery. There is a keen demand for the bituminous-small sorts which are somewhat scarce and correspondingly strong. On the other hand there is an ample supply of the dry steam smalls which are dull. Cokes remain active and patent fuel is steady.

Iron and Steel Industry.—Operators in the iron and steel and allied industries of South Wales and Monmouthshire are busily employed. A steady demand is manifest and, with order books well filled, the works are kept engaged practically to full capacity.

THE INSTITUTE OF ESTIMATORS—PLANNING AND TIME STUDY ENGINEERS.—Formed recently to enable members to meet and discuss various technical problems, the Institute of Estimators—Planning and Time Study Engineers is to hold a meeting at 2.30 p.m. on December 14 at the Waldorf Hotel, Aldwych, London, W.C.2. A paper entitled "Estimating" will be given by Mr. W. L. Morgan, F.I.I.A., F.C.I.S. The secretary, Mr. E. W. Barrell, 78, Abbotsbury-gardens, Eastcote, Middlesex, informs us that visitors are invited to attend the meeting.

STANDARDISATION OF MATERIALS IN BRAZIL.—A Brazilian Association for Technical Standards, the Associação Brasileira de Normas Tecnicas, known as the A.B.N.T., has recently been constituted. Although organised under the patronage of the Brazilian Government, it is independent of Government supervision and its main objects are to prepare and approve specifications for materials, and codes for the execution of engineering and technical works in Brazil. We understand that all the standards to be proposed by the A.B.N.T. will be accepted by the Federal Government and by the Governments of the various Brazilian States.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Although war production in this area has reached a higher level than was the case six months ago, industrialists are making efforts to increase production still further. Only a limited amount of ordinary commercial business is being done. Strict rationing of steel is being enforced, and the limited amount of steel now available for commercial customers is likely to be reduced still further. The raw and semi-finished steel-producing branches are operating at increased capacity. Basic billets are in strong demand, and larger tonnages of acid steel are being consumed. The demand for pig iron, hematite, and steelmaking alloys are being met satisfactorily, and no complaints of a shortage of such materials are being heard. The heavy machinery and engineering branches are exceptionally busy. Steelworks' and ironworks' machinery and related equipment are in strong demand. There is an increased demand for railway materials of all types. Among the items required are wheels and axles, springs, tyres, and buffers. Flat and coiled springs are being produced in larger quantities. The export of railway plant and materials has been severely cut down; orders are numerous, but difficulty is being experienced in obtaining the necessary export licences. Ship steel, forgings, castings, and deck furnishings are progressive lines. Electrical plant is in greater demand, and Sheffield works specialising in the production of high-efficiency steels used in the production of generators, transformers, etc., are busier than they were a year ago. Makers of agricultural machinery and parts are busy, the demand being well above the standard for this time of the year. The lighter trades are also active. Small-scale forgings and castings are in demand for various purposes, and the tool trades are increasing their outputs. Machine tools are in great demand, and engineers' small tools are being delivered in much larger quantities than was the case a year ago.

South Yorkshire Coal Trade.—Export business is still very difficult to arrange, and nearly all the output of the collieries in this area is going into home consumption; iron and steel works are taking increased supplies. Smalls and slacks are in good demand, as also is locomotive fuel. Steams are a strong section. The house coal market is satisfactory, and supplies are steady, while foundry and furnace cokes are moving freely to various parts of the country.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Active conditions still continue in the Scottish steel trade. Government contracts practically cover the current production and there is a steadily increasing demand for special high-grade steel for armaments. Steelmakers are being pressed for deliveries of ship and boiler plates, and structural sections are moving freely. Makers of black-steel sheets are still fully employed. Supplies of raw material are fairly good, but hematite iron is not very plentiful. The following are the current quotations:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black steel-sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade there has been little change. A good deal of work is in hand, but makers could produce a larger tonnage. Wrought-iron scrap is still scarce. The re-rollers of steel bars are not excessively busy, but the forward prospects are considered to be good. Stocks of semies, on hand and stored, are satisfactory. The current quotations are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade the demand continues to be of a very pressing nature and all the furnaces in blast are operating at full capacity. The consumption of hematite and basic iron is very heavy and the total production is rapidly absorbed. Foundry iron is not so active, but a fair business is being transacted. Good stocks of raw materials are available. To-day's market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

SHIPS DISCRIMINATION LIST.—No change is reported in either the Statutory List or the Ships Discrimination List, referred to in *The Board of Trade Journal* of November 8, except that the tonnage of the Carmen, a vessel flying the Spanish flag, shown therein as "about 350," has since been ascertained to be 199.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Nearly all branches of the iron and steel industry are very busily engaged and conditions generally are satisfactory. Interest is now focused upon the extent of clients' requirements for the first quarter of 1942; they promise to be extensive and pressing. Raw materials continue abundant and semi-finished products quite plentiful but the demand for certain descriptions of finished material is somewhat difficult to meet. Steelmakers have as much work as they can handle and, with increasing pressure for larger deliveries, doubt is expressed whether it will be possible to sanction any interruption of production at Christmas.

Cleveland Iron Trade.—Ample supplies of foundry iron are readily obtainable, though Cleveland qualities continue scarce. Licenses for the acquisition of parcels are issued freely and satisfactory deliveries of Midland pig and brands from other producing centres are arriving regularly for use in the Tees-side area. Consumers are quite well placed as regards supplies and would suffer little inconvenience from unforeseen temporary shortage of delivery. Light foundries have not a great deal of work on hand and are making liberal use of scrap, but the consumption of pig continues to increase slightly. Buying is still mostly direct from producers, but a little more tonnage than recently is passing through merchants. Fixed prices of Cleveland pig are based on No. 3 description at 128*s.* delivered to local buyers.

Basic Iron.—After meeting the heavy calls of their steel-producing plants, makers of basic iron are able to increase emergency stocks to some little extent, but they have not yet any tonnage to spare for the market and the official quotation remains nominal at 120*s.* 6*d.*

Hematite.—In the hematite industry some improvement in conditions may be reported though strict adherence to the control of distribution regulations is still necessary. Severe restrictions have enabled some stock to be accumulated; this, however, will doubtless be absorbed by essential needs in the near future, notwithstanding the large and extending use of substitutes. Consumption of refined iron in place of hematite continues to give satisfaction. The recognised market values of hematite are ruled by No. 1 grade of iron at 138*s.* 6*d.* delivered to North of England customers.

Foreign Ore.—The arrivals of foreign ore cover consumers' needs, but material for the production of hematite is still in somewhat short supply.

Blast-Furnace Coke.—Business in Durham blast-furnace coke is quiet, users having covered their requirements as extensively as they consider necessary, but recognised market values remain firm at the equivalent of good medium qualities at 36*s.* 9*d.* f.o.r.

Manufactured Iron and Steel.—The re-rollers have stocks of semi-finished iron and steel sufficient to keep their mills fully employed for some time to come as delivery of home-made semies promises to increase. The suspension of imports from overseas is not disturbing. Manufactured-iron firms are busy on heavy work, but could deal with orders for lighter commodities. Steel producers have as much work as they can carry out and as heavier calls are anticipated, as the arms drive gathers momentum, efforts to enlarge outputs still further continue. The pressure for larger supplies of special alloy steels is intense and the demand for tank plates is heavy. The delivery of shipbuilding requisites is satisfactory and the distribution of sheets meets the extensive requirements of customers.

Scrap.—Heavy grades of iron and steel scrap are still in brisk demand, but there is less request for the lighter varieties, users having largely covered their requirements.

FUEL LUNCHEON CLUB.—The next meeting of the members of the Fuel Luncheon Club will take place at the Connaught Rooms, Great Queen-street, Kingsway, London, W.C.2, on Friday, December 19, at 12.40 for 1 p.m. The after-luncheon address, entitled "Fuel: The Wide Aspect," will be delivered by Professor C. H. Lander, C.B.E., D.Sc., M.Inst.C.E. The office of the Club is at 30, Bramham-gardens, London, S.W.5.

AUSTIN MOTOR COMPANY MEDICAL DEPARTMENT.—A medical block, planned and equipped to commemorate the late Lord Austin, K.B.E., LL.D., J.P., was opened on December 3, at the Longbridge Works, Birmingham, of The Austin Motor Company, Limited, by Air Vice-Marshal Sir David Munro, K.C.B., F.R.C.S., secretary to the Industrial Health Research Board and Chief Medical Officer at the Ministry of Supply. The new department, a two-storey building situated near the main entrance to the works, has been designed so that all treatment can be carried out on the ground floor. There are treatment rooms for men and women employees, a ward equipped for the first treatment of serious injuries, and a room in which X-ray work and physiotherapy is carried out.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF PRODUCTION ENGINEERS.—*London Section:* To-day, 3 p.m., The Institution of Mechanical Engineers, Storey's-gate, St. James's Park, Westminster, S.W.1. "Sampling Inspection and Quality Control," by Dr. B. P. Dudding. *North-Eastern Section:* To-night, 6.15 p.m., The County Hotel, Newcastle-upon-Tyne. "Drop Forgings," by Mr. A. Chilton.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—To-night, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. "Plastics and Engineering," by Dr. A. Caress. *Student Section:* Wednesday, December 17, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne, 1. "Turbo-Blowers," by Mr. W. T. Atkinson.

INSTITUTION OF MECHANICAL ENGINEERS.—*South Wales Branch:* Saturday, December 13, 12.30 p.m., Macworth Hotel, Swansea. Luncheon Meeting. The Thomas Lowe Gray Lecture, by Major William Gregson. *Southern Branch:* Saturday, December 13, 2 p.m., Polygon Hotel, Southampton. Presidential Address: "The Position of the Locomotive in Mechanical Engineering," by Mr. W. A. Stanier. (To be preceded by a luncheon). *Institution:* Tuesday, December 16, 2.30 p.m., Storey's-gate, St. James's Park, S.W.1. Joint Meeting with THE INSTITUTION OF CIVIL ENGINEERS. (i) "Hammer-Blow in Locomotives; Can it not be Abolished Altogether?" by Sir Harold N. Colam and Mr. J. D. Watson. (ii) "Balance of Locomotive Reciprocating Parts," by Mr. E. S. Cox. Friday, December 19, 2.30 p.m. General Meeting. "The Axial Vibration of Diesel-Engine Crankshafts," by Mr. R. Poole.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, December 13, 2 p.m., Neville Hall, Newcastle-upon-Tyne. General Meeting. Informal Lecture on "The General Management of Pit Ponies," by Mr. F. Christopher.

INSTITUTE OF TRANSPORT.—*Metropolitan Graduate and Student Society:* Saturday, December 13, 2.15 p.m., The Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. "Air-Raid Precautions as Affecting Goods Road Transport (Horse and Motor)," by Mr. N. W. Sharratt.

INSTITUTION OF CIVIL ENGINEERS.—*North-Western Association:* Saturday, December 13, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. The Thomas Hawksley Lecture: "A Century of Tunnelling," by Mr. W. T. Halcrow.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North Midland Centre:* Saturday, December 13, 2.30 p.m., The Hotel Metropole, King-street, Leeds. "Metal Rectifiers," by Dr. A. L. Williams and Mr. L. E. Thompson. *North-Western Students' Section:* Saturday, December 13, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. "The Uses of Electric Power Underground in Coal Mines, with Special Reference to Flameproof Switchgear," by Mr. S. J. Humphries. *Institution:* Thursday, December 18, 5 p.m., Savoy-place, Victoria-embankment, W.C.2. Ordinary Meeting. "Voice-Frequency Signalling and Dialling in Long-Distance Telephony," by Dr. W. G. Radley and Mr. E. P. G. Wright.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Saturday, December 13, 2.30 p.m., The E.L.M.A. Lighting Service Bureau, 2, Savoy-hill, Strand, W.C.2. Illustrated Lecture: "Economics of Installation Planning," by Mr. H. M. Winstanley.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, December 13, 2.30 p.m., 39, Victoria-street, Westminster, S.W.1. Induction of Lord Sempill as President.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS.—Saturday, December 13, 6 p.m., at Messrs. Robert Hyde and Son, Limited, Stoke-on-Trent. "Internal-Combustion Engines," by Mr. F. Plant.

INSTITUTION OF AUTOMOBILE ENGINEERS.—*London Graduates' Branch:* Sunday, December 14, 2.30 p.m., 12, Hobart-place, Westminster, S.W.1. "Design Department," by Mr. J. B. Perrett.

IRON AND STEEL INSTITUTE.—Monday, December 15, 6.30 p.m., The Cleveland Scientific and Technical Institute, Corporation-road, Middlesbrough. Joint Meeting with THE CLEVELAND INSTITUTION OF ENGINEERS. "The Practical Side of Blast-Furnace Management," by Mr. R. R. F. Walton.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, December 16, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Influence of the Shape of Blade Sections on Singing of Propellers," by Dr. G. Hughes.

INSTITUTE OF WELDING.—*North-Eastern (Tyneside) Branch:* Thursday, December 18, 7 p.m., The Mining Institute, Newcastle-upon-Tyne. "The Welding of Boiler Drums," by Dr. H. Harris.

"BRISTOL" HERCULES III AERO ENGINE.

MESSRS. THE BRISTOL AEROPLANE COMPANY, LIMITED, BRISTOL.

(*For Description, see Page* 466.)

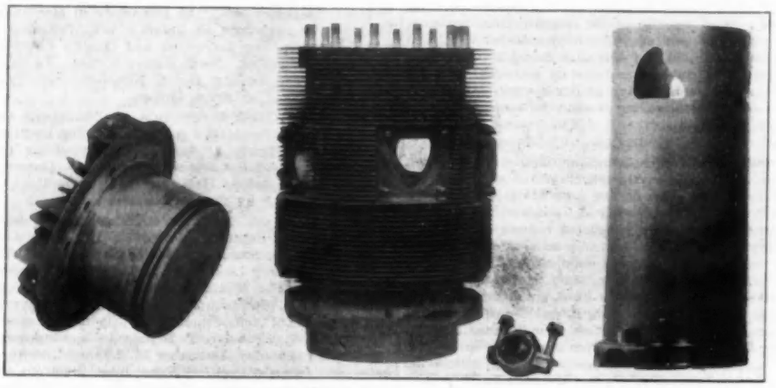


FIG. 5. CYLINDER HEAD, CYLINDER AND SLEEVE-VALVE.

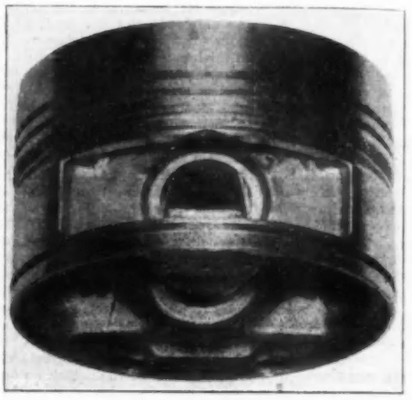


FIG. 6. PISTON.

FIG. 7. ASSEMBLY OF RADIAL SLEEVE-VALVE ENGINES.

DEVELOPMENTS IN TIN FOIL.

A NEW and improved tin foil, the primary purpose of which is the replacement of aluminium and zinc for milk-bottle caps, has recently been perfected by the Tin Research Institute. In the current issue of *Tin and its Uses*, Dr. E. S. Hedges, research manager of the Institute, states that many methods of comparing the merits of various foils were tried out and eventually a special tensile testing machine was designed, but it was kept in view that a tensile test is by no means fully representative of the performance expected of a bottle cap. With the co-operation of makers and users of these caps a wide range of foils was made up into caps which were used for sealing bottles in the laboratory, a special hand-sealing device being employed for the purpose. With the aid of an apparatus embodying an air compressor and a gauge, determinations of the internal pressure required to blow off each cap were made. This provided a measure of the "seal strength" of the various foils. The results of tensile tests had shown that an alloy containing 92 per cent. of tin and 8 per cent. of zinc, to which 0·15 per cent. of nickel had been added, possessed excellent properties from the point of view of strength and ductility. The internal-pressure test, however, showed that the addition of the nickel did not materially affect the seal strength. Consequently, since this addition introduces a complication in the manufacture of the foil without any corresponding advantage in the seal strength of the cap, it has been decided to dispense with it. Some hundreds of tons of the new bottle caps are in course of manufacture, and the current programme calls for several thousands of tons annually of the 92 per cent. tin, 8 per cent. zinc alloy, which has been accepted as meeting present requirements completely

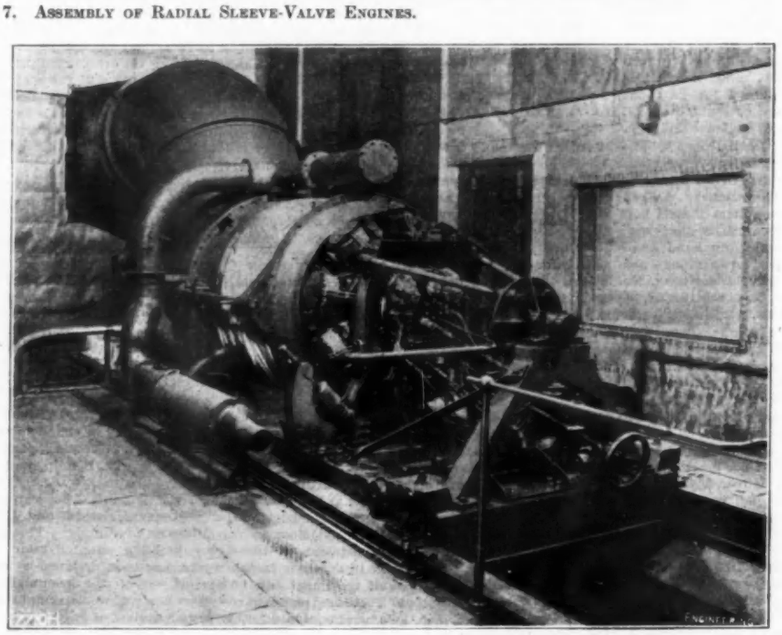


FIG. 8. ENGINE UNDER TEST.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

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TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730 and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, DECEMBER 12, 1941.

VOL. 152. No. 3961.

WORLD WAR AND MAN-POWER.

ON Thursday, December 4, the House of Commons passed, by a majority of 316 out of 326 votes cast, the Prime Minister's motion "That, in the opinion of this House, for the purpose of securing the maximum national effort in the conduct of the war and in production, the obligation for National Service should be extended to include the resources of woman-power and man-power still available; and that the necessary legislation should be brought in forthwith." If the House had shown any hesitancy in doing so, the Far Eastern events of only three days later must have dispelled it as effectively as they have obliterated the Isolationist opposition to President Roosevelt's policy in the United States. The British Government and the British people might have thought that, having experienced German methods of war-making twice in a quarter of a century, they had nothing more to learn about the possibilities of totalitarian duplicity on the grand scale; but the Japanese High Command has demonstrated that, expert and unscrupulous copyists as the people of that nation have shown themselves to be in so many technical and industrial fields, they are still capable of a diplomatic originality which need concede nothing to the most unsavoury episodes of Occidental history, or even of their own. The distinction that they have now achieved is one which is unlikely to excite either envy or competition, save among their Axis associates; and even in those quarters it can hardly inspire confidence.

The principal effects of the latest developments upon the British war effort are two-fold. In the first place, they institute a new battle-front (if "front" is a term that can be reasonably applied to an area of ocean extending thousands of miles in each direction) which presents problems of transport and supply of a more difficult character than any nation has ever faced before; and, in the second place, they involve the diversion to that new front of a great part of the American output of munitions of every kind which, otherwise, would have been sent to this country and to Russia. Not only does the first consideration imply demands upon the available reserves of shipping that represent an appreciable added burden, but the probability that an extension of the present use of convoys will be necessary still further reduces the effective carrying capacity of the Allied mercantile fleets by imposing speed restrictions in waters where, hitherto, they were not required.

The net effect of all these circumstances upon the British munitions industry is to add materially to the load that it is already carrying and to strengthen the demand of the Government for an immediate increase in the industrial personnel, and in that of the three Services. It is well, therefore, to place on record the nature of the changes contemplated in framing the proposals of the new National Service Bill. Briefly, they are as follows. The Bill proposes to amend the present National Service Acts so as to raise the upper limit of age from 41 to 51, and to call youths to serve at the age of 18½ instead of at the previous lower age limit of 19. It is intended, also, to extend the scope of the Acts to include women (in the first place, between the ages of 20 and 30), who will be given the option of serving in the Auxiliary Forces, in Civil Defence, or in certain branches of industry. The present system of block reservation under the Schedule of Reserved Occupations, it is proposed, should be abolished and gradually superseded by a system of individual deferments, the ages of reservation as shown in the latest Schedule being increased by one-year steps at intervals of a month, beginning on January 1, 1942. Existing deferments are to be cancelled, in the case of men under 25, except in certain occupations of prime importance; and boys and girls are to be required to register at the age of 16, and will be interviewed by the Youth Service Committees of the Education Authorities, with a view to their being encouraged to join appropriate organisations in which they will be prepared for active participation in the national effort when they attain the age of 18. The claims for individual deferment will be investigated by newly constituted District Man-Power Boards, and those applicants to whom deferment is not granted will be either transferred to more essential occupations or will be called up for the Forces. The scheme for the supersession of block reservation by individual deferments is not to apply to certain special classes of men; and those engaged in agriculture, building, coal-mining, and the Civil Service will be subject to special schemes of deferment.

It will be obvious that the intentions of the Bill, if they are fully implemented in practice, will affect the entire structure of industry, not excepting those branches which are now almost wholly occupied in war production; and, in the debate in the House of Commons on December 2, 3 and 4, there was no lack of speakers to urge that the Government should look first to the full and efficient employment of the personnel already engaged in munitions production and in the Services themselves before compulsorily denuding the so-called "non-essential" occupations of their remaining labour force and thrusting more thousands of men and women into the war factories. Anyone with first-hand experience of factory administration on any extensive scale must be perfectly well aware that it is no more possible to employ all the people all the time than it is, as Abraham Lincoln declared, to fool them all the time; but, after studying the official report of the debate with some care, we incline to the view that some of the instances of time-wasting that were adduced by the Government's critics were dismissed rather lightly. The significance of some of the cases may have been unintentionally exaggerated, but there were sufficient of them, in the aggregate, to constitute a somewhat serious indictment, and there is no reason to suppose that those instances cited constitute the whole, or even a majority, of those that have occurred and still persist. Assurances were given, once again, that any such complaint would be investigated if the necessary data were forthcoming, and that, in exercising their power to direct men and women into more essential work than they had been doing, the responsible authorities would be as strict with the Forces and the Civil Service as with industry, and private individuals.

While the operation of the new Bill, when it becomes an Act, will provide a considerable accession of technically trained men to the Forces, this effect must take time to develop; whereas the rapid expansion of the various arms which depend upon

technicians for their employment—and, indeed, for their existence—calls for a more immediate recruitment of qualified engineers of many kinds. This is a problem which cannot be considered by itself, for it is inextricably bound up with the concurrent needs of the Supply Departments and of industry. Since the outbreak of the war, it has engaged the continued attention of the Councils of the leading engineering institutions, who have been working in close collaboration with the Ministries concerned, to ensure that the training and professional skill of their members and students shall be applied to the best advantage. The Government are equally aware of the importance of recruiting the most suitable personnel for the responsible work of the rapair and maintenance of armoured fighting vehicles, transport, artillery, aircraft, etc., and recently appointed a Technical Personnel Committee, under the chairmanship of Lord Hankey, to deal with questions relating to the demand and supply of engineers of professional, or approximately professional, standards. This committee includes representatives of the Ministry of Labour and National Service, the Service and Supoly Departments, the Board of Trade, the Ministry of Works and Buildings, and the Board of Education. Through Dr. A. P. M. Fleming, it is linked with the Engineering Advisory Committee, and it is in direct contact, also, with the War Cabinet.

Hitherto, the necessary intake of technically trained officers has been provided largely from within the Services, but partly also by the normal output from the universities and technical colleges and by the engagement of volunteers over the age of reservation. These resources, however, are insufficient to meet the present need and it has been decided, therefore, to review the cases of all the young engineers in civil employment, and of appropriate qualifications, who were under 25 when they registered for military service. The intention is that those who are suitable shall now be called upon, and recommended for consideration for commissions. All holders of university degrees or of Higher National Certificates in engineering, within the stated age limit, are affected by this decision, whatever may be their present positions according to the Schedule of Reserved Occupations. Simultaneously, the Beveridge Committee, which has been investigating the employment of skilled men in the Services, will extend its survey to cover officer grades, to ensure that they are being effectively used; and, at the request of the Lord President of the Council, the Supply Departments are reviewing thoroughly the employment of technical personnel in their respective establishments.

The withdrawals of young technical men from industry will raise many problems of replacement, and it is to meet these that the Board of Education and the Scottish Education Committee have instituted the scheme for intensive training of young engineers, which was the subject of an editorial reference on page 394, *ante*. Under this scheme, youths will be withdrawn from industry at the educational level of the Ordinary National Certificate or the Inter. B.Sc. and, having completed the special six-months' intensive course, will be available for employment at the level of the Higher National Certificate, in substitution for those who have joined the Forces. Inevitably, there will be certain difficulties in the way—for instance, in some districts it will be necessary to call on local industrial establishments to release some of their staff men on a part-time basis to supplement the teaching staffs of technical colleges—but there is reason to believe that these will prove less acute than might appear at first sight; and there is no question that, to the trainees themselves (who will receive free tuition and subsistence allowances on which they should be able to live without other financial support) the opportunity is one presenting many possibilities of advancement.

The state of the engineering industry as a whole has undergone considerable changes since the outbreak of war, and, even in the "heavy" branches, it is now largely on a repetitive basis. The amount of new design work, estimating, experimental development, etc., is appreciably less than it was, and, although the output continues to increase, the demands thus entailed fall rather upon the production side of the industry than what may be termed the initiating side. It is probable, therefore, that the technical staffs can now help more effectively to meet the requirements of the Services for technical officers than they could have done even a year ago. Simultaneously, the needs of the Services have also changed. The Royal Navy now has vacancies for engineer officers up to 40 years of age, and even to 45 in some cases, for the Electrical Branch and for aircraft maintenance duties. The Royal Marine Engineers are giving commissions to civil engineers, with experience of heavy constructional work, up to the age of 45; the Royal Army Ordnance Corps age limits now range from 21 to 50; and those of the Royal Air Force are the widest of all—from 19 to 60. The professional qualification demanded are, broadly, those of the technical institutions in each case, and the prospects are unquestionably attractive.

THE REGENERATIVE STEAM CYCLE.

THE question of the proper criterion with which to compare the performance of a steam turbine working on the regenerative feed-heating cycle has been raised once more by a paper appearing in the current issue of the *Proceedings* of the Institution of Mechanical Engineers. The author, Mr. H. S. Horsman, expounds at considerable length a method he has devised for calculating the efficiency of a regenerative cycle, taking into account the number of feed-heating stages employed. His object is to provide a means whereby the theoretical efficiency of an ideal plant with any usual number of feed-heaters can be determined, and thus to establish a standard with which the performance of an actual plant, designed for similar conditions, may be usefully compared. The heaters he envisages are ideal ones, in the sense that they are capable of raising the temperature of the feed-water to the full temperature of the steam supplied. They are, however, far from ideal from the thermodynamic point of view, because, as they are limited in number, the water must enter them at a temperature sensibly less than that of the steam which is used to heat it. The consequence is that there is, in each heater, a temperature drop that is not productive of the work of which it is theoretically capable; and an irreversible thermodynamic process goes on which is incompatible with the ideal cycle.

This defect is inherent in the whole principle of regenerative feed-heating by finite stages. No plant, therefore, which embodies this principle, however theoretically faultless it may be in other respects, can ever attain the efficiency attributable to a perfect engine. To achieve this efficiency, there must be no irreversible heat flow taking place anywhere in the system. The Rankine cycle, in which the feed water is heated in the boiler, does not, of course, fulfil this requirement, but its limitations are well known and accepted. The only way of heating the feed water reversibly, apart from adopting the Carnot cycle, is to heat it regeneratively by an infinite number of stages, so that the process becomes virtually a continuous one. Any other assumption would result in the absurd conception of a perfect engine, the efficiency of which could be improved upon.

The problem of determining the theoretical efficiency of any heat cycle, whether regenerative or not, is merely that of calculating the maximum amount of work that could possibly be developed by the change of state of the working fluid. The equipment of the engine which may be imagined to produce this work does not enter directly into the picture. The only requirement is that the engine shall be a perfect one; that is to say, it shall be conceived as being capable of turning the whole of the available heat into work. If this condition can be fulfilled, nothing else matters, and the number of feed-heaters employed is of no more importance than the number of bearings in the engine. All that is demanded of an ideal engine is that it shall function without either frictional or thermal losses, and it is this latter stipulation, as we have already seen, that makes it necessary to imagine it to be provided with an infinite number of feed-heaters if it is to operate on a regenerative cycle. This conception calls for no more imagination than frictionless bearings and heat-proof cylinders which have been accepted without demur in thermodynamical calculations. It has the great advantage, moreover, of so simplifying the calculation of the basic efficiency of a regenerative cycle that this can be obtained at once from an elementary formula; due originally, we believe, to the late Captain H. Riall Sankey, and quoted by Mr. Horsman in an appendix.

There is an interesting theoretical point which arises in connection with regenerative feed-heating when the heating steam is withdrawn from the turbine in a superheated state, a condition frequently met with in modern plants. Saturated steam entering a heater can give up its latent heat to the water by condensing at the same temperature, and therefore (theoretically, at any rate) without any irreversible temperature drop being incurred in the process. Superheated steam cannot behave in this way. If heat is abstracted from it at constant pressure, its temperature must fall and this temperature drop, under happier circumstances, might have been employed in doing mechanical work; but no work is done in the heater, so that it would appear as though superheated steam could only be used for feed-heating at the expense of incurring a definite thermodynamic loss. Were this true, it would limit the ideal engine to the use of saturated or wet steam in its feed-heaters, and thus render it impossible, in an ideal cycle, for the feed-water to be raised regeneratively to full boiler temperature by means of partially expanded steam drawn from the turbine.

This difficulty was considered by the late H. M. Martin, who did so much to promote a better understanding of thermodynamics. He pointed out that it could be surmounted by imagining the ideal engine to be provided with an ideal compressor. This would be employed in compressing the superheated steam isothermally, the work so expended being the exact equivalent of the heat given up by the steam to the feed water. The whole process would then become thermodynamically reversible, and therefore consistent with the requirements of an ideal cycle. The ideal engine operating on this cycle, being a purely imaginary one, might just as well have a compressor incorporated in it as not, especially as the existence of such a compressor in no way complicates the calculation of the ideal efficiency of the plant. For the determination of this efficiency, all that is needed is a knowledge of the total heat and entropy of the live steam, the total heat and entropy of the feed-water in its heated condition, and the temperature prevailing in the turbine condenser. These figures can all be obtained directly from the Callendar or other steam tables, and are to be used by means of the formula referred to above.

The considerations which we have brought forward appear to lead inevitably to the conclusion that the basic efficiency, which is to be used as the criterion of the performance of a turbine working on the regenerative cycle, can and should be computed without reference to the number of feed-heaters actually employed to raise the feed-water to its final temperature. If this be admitted, the greater part of Mr. Horsman's paper must be regarded as beside the point. There remains only the question whether the method he proposes might be serviceable to the designer who wishes to forecast the results likely to be obtained with any given number of heaters. In this respect also, we fear that its utility will be limited. It is very unlikely that a designer would want to arrange his heaters so that each would be responsible for the same proportion of the whole temperature rise of the feed water, and it is absolutely certain that he would never attempt the impossible task of designing them to give an exit temperature of the water equal to that of the incoming steam. Both these conditions, however, are assumed in Mr. Horsman's calculations, which, therefore, have no very direct relation to realities. It is unfortunate that the paper could not have been presented at a meeting of the Institution, for the result might have done much to clarify opinions on the question at issue. It is open for discussion in writing, however, and may be expected to arouse considerable interest.

NOTES.

PAPER SALVAGE AND ECONOMY.

A SPECIAL appeal to consulting engineers and engineering firms, having offices in Westminster, is being made by the Mayor (Mr. W. Stanley Edgson) in connection with the city's Paper Salvage Week, which commences on Monday next, December 15. Apart from the urgent need to collect waste paper for the production of munitions, there is the added inducement that an anonymous donor has offered to contribute, for every ton of paper collected during that week, the sum of 10*l.*, to be divided between the various charitable organisations for seamen, soldiers and airmen. Whether the paper is handed to the City Council's collectors or disposed of through waste-paper merchants, its weight will be added to the total and will benefit the country and the several benevolent funds of the Services accordingly. Arrangements have been made to give the fullest publicity to the scheme for collecting the paper, but any information desired can also be obtained from the Salvage Officer, Alhambra House, Charing Cross-road, Westminster, London, W.C.2 (telephone ABBey 5328). The need for all possible salvage of paper continues to be great, but, as we have stated before, the need for economy in its use is no less important, and even the seemingly minor economies should be practised steadily. In one such method, we can collaborate usefully with our contributors. It has always been customary for authors' manuscripts to be written on one side of the paper only; a requirement that has a thoroughly practical basis, as it avoids one possible source of error in typesetting, and simplifies appreciably the work of the compositor. In present circumstances, however, we are prepared to waive this rule, even though, in so doing, we are adding to the work of our attenuated editorial staff. We must request, however, that matter shall be typewritten wherever possible, and with open spacing and good margins, to allow room for the notes and "marks" that must usually be added before the MS. goes to the printer. The requirement of open spacing may appear to negative the economy that we are urging; but, in fact, this is not so. There have been occasions when a contribution, of high technical quality, has filled the sheets so completely that it has had to be retyped before it could be used; a contingency that it is obviously desirable to avoid at any time, but especially at the present.

MILITARY PREPARATIONS IN THE UNITED STATES.

An authoritative survey of the work involved, and largely completed, in the expansion of the United States Army was given by Brigadier-General, War Department, in Chicago, on October struction Division, Office of the Quartermaster-General, War Department, in Chicago on October 15, when he addressed a joint meeting of the American Society of Civil Engineers and the Chicago Chamber of Commerce. At the present time, said General Somervell, "more than a million soldiers are newly housed in the finest quarters and training camps ever built for such purposes by any nation, anywhere"; although "a year ago, the draft had not yet gone into effect and the construction programme had just begun. To the Construction Division fell the responsibility of building, first, troop shelters for approximately a million and a quarter officers and men; and, second, facilities for the manufacture or storage of arms, ammunition, equipment and supplies. The first responsibility has been discharged; all essential troop housing was in readiness by the end of June, 1941—at all periods of construction after March 15, there was actually a surplus capacity over requirements of about a quarter of a million beds. Subsidiary only to the raising of a modern, competent, striking force was the provision of ammunition and weapons. Many of the ordnance plants, like the camps, hospitals, harbour defences, storage depots, air facilities, and other projects launched little over a year ago, are now going concerns. They represent only the first battery of assembly lines to be thrown into the war of production. In 1942, approximately thirty more ordnance factories of a similar nature will add their weight of output to the spectacular volume of lead and steel. The first army to take the field was the Construction Division, at one time nearly 500,000 strong. To-day it still numbers over 400,000 and is working in double shifts on production and storage facilities, and four new division camps are now under construction. As a result of advance planning, work was in readiness to begin at once when funds became available. Camp Gordon, near Augusta, Georgia, and Camp Crowder, near Neosho, Missouri, are being built under fixed-fee contracts. Camp Chaffee, near Fort Smith, Arkansas, and Camp Cooke, near Santa Maria Lompoc, California, are being built under unit-price contracts awarded after public bidding. Under the present contracts in force for these four new camps, for the expansion of existing manufacturing plants, and for the construction of new ones, the current activities of the Construction Division approach the scope of the initial programme. The Air Corps facilities, being provided by the Engineers, are even greater than before. Much as we appreciate the gallant stand of our defenders on the other side of the water, we are not helping them for either charity or sentiment. It is a matter of self-interest, dictated by necessity. Let us be honest about it. Only by redoubled effort, by the toil and sacrifices of every American citizen, can this job be done. That way, and that way alone, lies freedom for America. It is better to work now with everything that is in us rather than wait, wait, lose—and be enslaved to-morrow."

PAYMENT BY RESULTS IN THE BUILDING INDUSTRY.

On page 453, *ante*, we referred to the fact that the Government had decided to extend the principle of payment by results to the maximum extent in connection with the construction of all scheduled factories, hostels, transport and port works, aerodromes and other vital war installations. At the end of our note we referred to an official panel which the Minister of Works was to appoint, with the assistance of the Federation of Employers and the employees' organisations in the building and civil-engineering contracting industries, to advise him on all problems arising out of the establishment of the scheme. This panel has now been constituted and comprises Messrs. H. C. Harland, G. H. Parker and T. L. Wallis, of the National Federation of Building-Trade Employers; Messrs. R. Coppock, L. Fawcett, J. W. Stephenson, and B. Sandercock, of the National Federation of Building Trade Operatives; Messrs. G. M. Burt, A. M. Holbein and H. T. Holloway, of the Federation of Civil Engineering Contractors; Messrs. T. Pugh and H. Bullock, with Mr. C. L. Skinner as an alternative delegate, appointed by the Civil Engineering Conciliation Board (Operatives); and Mr. G. T. W. Fairbrass, of Messrs. Corderoy and Company, appointed as independent quantity surveyor. A first meeting of the panel has already been held under the chairmanship of the Director-General, Ministry of Works and Buildings. It is intended to refer to the panel all questions raised from sites in regard to the scheme, in which any matter of policy or interpretation is involved. As a result of the decisions of the panel it is hoped to create, in time, a code which will be understood and operated throughout the country.

EFFICIENCY IN THE USE OF FUEL.

At the request of the Mines Department a series of meetings has been arranged jointly by the Institutions of Civil, Mechanical, Mining, Electrical, Gas, and Chemical Engineers, the Institute of Chemistry, the Iron and Steel Institute, the Society of Chemical Industry and the Institute of Fuel. The object of the meetings is to promote open discussion on the best ways and means of improving the efficient use of fuel and power in existing industrial plants, under present conditions, and to invite constructive suggestions. The first of the series of meetings will be held at 2.30 p.m., on Tuesday, December 16, in the Large Hall, College of Technology, Sackville-street, Manchester. The chair will be taken by Sir Robert Burrows, J.P., chairman of the Lancashire Associated Collieries, Limited. The discussion is to be opened by Dr. F. S. Sinnatt, F.R.S., Director of Fuel Research and member of the Fuel Efficiency Committee of the Mines Department. The second meeting will take place at 2.30 p.m., on Saturday, January 3, 1942, in the Large Theatre, H. H. Wills Laboratory, Royal Fort, Bristol. The chair will be taken by Sir Richard Redmayne, K.C.B., and the discussion will be opened by Mr. J. G. Bennett, member of the Fuel Efficiency Committee of the Mines Department. The third of the meetings so far arranged will be held at 2.30 p.m., on Thursday, January 8, 1942, in the Lecture Theatre of the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. The chair will be taken by Sir Harold Hartley, C.B.E., F.R.S., chairman of the Fuel Research Board. The discussion will be opened by Dr. E. J. Grumell, chairman of the Fuel Efficiency Committee of the Mines Department. All persons interested in the subject of the efficient use of fuel are invited to attend the meetings, for which tickets are not required.

INSTITUTE OF TRANSPORT EXAMINATIONS.

The Council of the Institute of Transport has announced that three amendments have been made to examination regulations of the Institute. In the first place, the pass list, in future, will show candidates who have distinguished themselves as having been awarded 1st class or 2nd class honours. Secondly, the existing regulations Nos. 6, 7 and 8, relating to the admission of young men to studentships, have been cancelled. The new regulation states that there is no studentship examination, but candidates will be regarded as qualified to apply for election as students if they have passed the School Certificate examination or some other general educational examination of similar standard, acceptable to the Council. Failing this, they must be able to satisfy the Council that they have reached a good educational standard and are capable of pursuing satisfactorily courses of study for the graduateship and associate-membership examinations of the Institute. Thirdly, the following regulation has been added to those for the associate-membership examination: Candidates, who are not less than 35 years of age and who are able to satisfy the Council that they are suitably qualified by education and experience, may be permitted to submit a thesis in lieu of taking the associate-membership examination. An application for permission to present a thesis must include the proposed title and a synopsis. The completed thesis must be submitted in duplicate and accompanied by the associate-membership examination fee, a declaration that it is the candidate's own work, and the names of two corporate members who can certify that declaration. The thesis must show practical and theoretical knowledge of transport and should be a record of original thought or research. Importance will be attached to the literary presentation of the thesis.

GOVERNMENT CONTROL OF FACTORY PREMISES.

In ENGINEERING of May 9, 1941, page 374, notice was given of the establishment by the Board of Trade of a Control of Factory and Storage Premises, designed to enable the best use to be made of available industrial space and to obviate wasteful competition by Government departments. The Order came into operation on May 15; and on December 5, Sir Cecil Weir, the Controller-General, gave some particulars of the work of the Control during its first six months. The basic information on which the work of the Control was organised was obtained from returns covering some 40,000 factories or storage premises, and providing details of the buildings, the employees, the services, and the work carried on. This information was tabulated, and appropriate sections were circulated in the twelve Civil Defence regions in which Regional Controllers had been appointed. The requirements of all the Government departments were made known to the Control and, from the register of premises, suitable buildings, not already in use for essential purposes, were selected. As the register shows what work is already in progress in any particular building, it is possible to acquaint the departments of the measure of protection which a factory needs and so to avoid fruitless inspections. Since it came into operation, the Control has allocated nearly 50 million cubic feet of space, one third being for production and the remainder for storage. Much of this space has

been rendered available as a result of the policy of concentration of production in many industries manufacturing the less essential goods. Thus, torpedoes are now being made in a former shoe factory; anti-gas and medicated ointments are being produced in what was a beauty-cream factory; aero-engine parts are being made in a works which had made hairpins; and aeroplane frames in a toy factory. Buildings that are unsuited to war production, or which are situated in districts where the available labour, housing or power are inadequate, are being used for storage purposes; many of them for footstuffs, such as sugar, flour, and canned goods. Food is now stored in more than 10,000 such depots. A former weaving factory has been converted, by the removal of the machinery from its five floors, to accommodate naval stores from the Royal Dockyard at Devonport. Other buildings, not in use and apparently overlooked by the Factory Control, may be, in fact, one of the "Emergency Pool" premises which are kept in readiness to rehouse some essential production unit which may have suffered damage by enemy action. Such buildings are being held in reserve all over the country. They have been inspected, reconditioned when necessary, and approved by the production departments, each of which will have its claim to be rehoused investigated immediately after a raid has interfered with any of its particular branches of war production.

The Hoover Medal.

The Hoover Medal Board of Award, consisting of representatives of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, have decided that the fifth recipient of the Hoover Medal shall be Mr. D. Robert Yarnall, "humanitarian, engineer, and a leader in the engineering profession." The Medal was formally instituted on April 8, 1930, during the celebration of the jubilee of the American Society of Mechanical Engineers, to commemorate the civic and humanitarian achievements of ex-President Herbert Hoover, to whom the first award was made. The second recipient was Dr. Ambrose Swasey, in 1936. The third Medal was awarded to Mr. John Frank Stevens, in 1938; and the fourth to Mr. Gano Dunn, in 1939. The Medal is provided out of a trust fund established in 1929 by Mr. Conrad N. Lauer, Fellow of the American Society of Mechanical Engineers and president of the Philadelphia Gas Works, and is held by the Society. Mr. Yarnall is also a Fellow of the Society, and served as a member of the Board of the Engineering Foundation. He has been associated with the American relief work in France, in co-operation with the Red Cross, and is chairman of the Refugee Section of the American Friends' Service Committee.

The War in the Pacific.

Just as this issue was being prepared for press, the brief official announcement was made that H.M.S. Prince of Wales, the flagship of Admiral Sir Tom Phillips (Commander-in-Chief of the Eastern Fleet, based on Singapore) and H.M.S. Repulse have been sunk in an attack by Japanese naval aircraft. No further details have been issued, save the information in a Japanese bulletin that the Repulse was sunk immediately and that the Prince of Wales, after being badly hit in the same attack succumbed to a second, some 20 minutes later. The news was given to the members of the Institution of Naval Architects, at their luncheon on Wednesday, December 10, by Lord Hankey, who had taken the place of the Rt. Hon. A. V. Alexander, First Lord of the Admiralty. Further reference was made to it by Lord Chatfield, the newly-elected President of the Institution; who observed, however, that, serious as the loss was, only three British battleships had been sunk in two years of war. Apparently, Lord Chatfield was including the Hood in this category. It is possible that submarines as well as aircraft were concerned in the attack for it to have been so speedily effective against a ship of such recent design as the Prince of Wales, which went into service only some eight months ago, and is known to have been provided with extensive anti-aircraft protection.

ECONOMIC CONTROL IN INDUSTRY.

By F. L. Meyenberg, M.I.Mech.E.

(*Concluded from page* 314.)

The previous article dealt with the fixed property of a works. In this concluding instalment, it is necessary to return to the floating property. One main item, material, was the subject of the second article; the second item, money, in its various forms, is rather outside the present survey. But while the former consideration of material was mostly concerned with it when in the state of rest, that is, in the various stores, it is now the movement of material that must be discussed. The main principle must be that the movement of material should proceed as quickly, but as continuously and uniformly, as possible. The application of this principle has often called for a complete revision of the arrangement and internal organisation of a works, the characteristics of particular shops depending less upon the uniformity of output of tools or men than upon the sequence of operations on the parts being produced. The retention of semi-finished goods in the shops should be avoided and transport reduced as much as possible. This principle of continuous and equal flow of work can be applied more easily when the nature of the product permits the full use of tolerances, gauges, and standardisation in the widest sense.

How far this development is possible depends not only on the kind of goods to be produced, but especially on how close an approach to mass-production can be attained without endangering the economic result. There have been cases where undue preoccupation with the idea of quantity production without regard to the extent of the market had a disastrous effect on the whole undertaking; but there is no question that the full possibilities of these principles have not yet been exhausted. The requirement that the product shall be "just good enough," so that the customers' needs are met, but that the quality and accuracy of finish shall not be higher than necessary, is still considered in some circles as leading to a lowering of the high standard made possible by long years of development; but this overlooks the fact that working up to the limit of attainable quality and accuracy results only too often in a waste of capital, as new inventions, change of fashion, etc., may make the product obsolete before it is worn out by natural wear and tear that has been reduced to the utmost by unduly high quality and accuracy. Here limit gauges are an excellent guide; but in many shops they are still unknown. Frequently it is said that the use of limit gauges is one of the reasons for the decrease in manual skill, so often deplored. The writer's long experience leads him to question whether this decrease in skill has taken place at all; but, assuming it to be true, the use of limit gauges cannot be blamed for it. On the contrary, by giving a real measure of accuracy where previously there was only an instinctive feeling, they train men to work accurately, and give at the same time a means of control that allows for an objective classification of accuracy.

A similar observation can be made with regard to standardisation, and its application or neglect in practice. There are few to-day who would not admit that standardisation can reduce production costs; but public opinion, influenced by imperfect understanding or by the arguments of interested parties, often condemns standardisation as opposed to the development of individuality, or as rendering life dull and boring. No doubt, excessive standardisation can have such consequences, but in this it is no worse than any other method of organising. Applied within reason, it is one of the most important means of effecting economy. How far this is true can be judged from a general definition of what standardisation in works really implies, as laid down by the German Standards Institution as recently as a year ago. Standardisation, it was then stated, is the comprehensive and systematic regulation of a multitude of facts in order to obtain as definite an arrangement as possible. A standard is the uniform solution of a repeated problem. Of special importance is the technical science, practice and economics of that kind of standardisation which has arisen from the co-operation of all concerned, as a result of economic thought and action. It deals with ideas, units, qualities, quantities, shapes and dimensions, substances, tolerances, testing methods, ways of delivery, methods of calculation, costing and accountancy, printed forms, directions for construction and use, safety regulations, etc. Two special kinds of standardisation can be considered in this connection: (1) where quality, quantity and form are fixed for a special product, but for different dimensions, and a series of types results; or (2) if a series of terms is stipulated, on which the acceptance of the goods depends and which may be of a technical or commercial nature.

It must be the task of the management to make use of these fundamental ideas of the continuous flow of work, of the principle of "just good enough" and of standardisation, in a manner best suited to the undertaking in hand; and the methods which show whether, and how far, that aim is attained may be regarded as an extensive production research that goes on continuously, although it is rarely known under this name. It consists, as already mentioned, mainly of testing and inspecting, of organisation studies, and of work and time studies; but the connection between the activities indicated by these headings is seldom fully recognised in practice. Too often the work of the inspection department is looked upon in the light of an intrusion, interfering with actual production; and it is not unknown for the production engineer to regard the time-study man, or (as he is sometimes unfortunately termed) efficiency engineer, in the same light.

Inspection is often too limited in scope to effect as much benefit as its results should render possible. Its function is to compare the actual with the ideal; not an unattainable ideal, but a practical one, representing a reasonable compromise between the technical, economic and psychological considerations. Deviations of the actual from the ideal standard, as shown up by the inspection, should be regarded less as a reproach to the production side of the organisation than as a guide for improving the manufacturing process, or sometimes as an invitation to see whether the standard is still correct or ought to be changed to suit changed conditions. In both cases, the time-study engineer could help to ascertain the reasons for the facts disclosed by the inspection: another instance of the close connection that exists between the work of the inspector and that of the time-study man, which makes animosity between them unreasonable.

The work of the time-study engineer is perhaps the most disputed in industry. While there are, among both managements and workpeople, some who refuse entirely to consider it, there are others who would apply it as a universal remedy in all difficulties; and all shades of opinion can be found, between these two extremes. The writer, having devoted many years of his professional life to its theory and practice, would give a warning against exaggeration in either direction. Time study is an excellent instrument of production research—perhaps, in some cases, the only one that could be recommended—but, like all instruments, it can do its best work only in the hands of an expert; and such an expert is not created by putting a stop-watch in the hands of a man who has just finished his apprenticeship or taken his degree. This is not the place to go more deeply into the essentials of time-study work, the subject of an extensive specialised literature, one of the most recent additions to which is a volume of more than 500 pages*; but some general features may be pointed out that are too often overlooked, which may have contributed to the distrust of this excellent method of research, still found in some quarters.

As time studies were made originally as a check on the payment of the employees, the idea has taken root that the development of fair piece-work wages is the main, if not the only, reason for them. Ad-

* *A Primer of Time Study.* By F. W. Shumard. London: McGraw-Hill Publishing Company, Limited (1940).

mittedly, in many cases a reliable basis for piecework rates can only be found by means of time studies, but this is not their sole purpose, nor is time study the only means of attaining that end. In the writer's opinion, a more important application is the use of this kind of research work to improve production methods and processes. These improvements may seem self-evident afterwards, but many of them would never be brought to notice and carried out if some such systematic investigation had not taken place. Furthermore, work and time studies can form a link between production, on the one hand, and costing and accountancy, on the other, branches which, unfortunately, are frequently at variance. It might almost be said that the modern development of costing, based on the idea of standard costs, could hardly be put into practice without the help of such studies. The general development of production standards planning, and its financial counterpart, budgetting, depend largely on these investigations. Last, but not least, it is an excellent expedient for increasing the mutual understanding between management, staff and men. Special emphasis should be laid on this last statement, as, unfortunately, mistakes in applying time studies in the early stages of this kind of work have created a widespread antipathy to them; though this should diminish with increased knowledge of how to make them correctly, and with the growing power of trade unions to protect the men against misuse of this form of production research.

Organisation studies are unknown in too many works; largely because organising is considered so simple that it can be done satisfactorily without any detailed investigations, and even by people not specially trained. How wrong this opinion is can often be shown by developing an organisation plan for a works, showing the functions and relative position of each member of the staff. Almost invariably, where such organising is regarded as unimportant, it is found that there is overlapping of duties, contradictory instructions, duplication of work, etc., leading to friction and wasted effort.

Besides the measures of economic control that have been discussed, there is a second group, best summarised, perhaps, as "industrial accounts" and comprising, mainly, accountancy, costing and statistics. While the technician will generally agree that the first group has close associations with his own work and considers those concerned with it as belonging to his own profession and entitled to any help that he can give, his interest in the second group is usually small. He has rarely any opportunity to study in detail the work of the accountant and does not care for it as long as it is not brought unpleasantly to his notice by the fact that balance sheets or profit and loss accounts appear to show his own activities in an economically unfavourable light. This is a very unsatisfactory state of affairs and everything possible should be done to further the mutual understanding of the two departments. Unfortunately, that is not easily accomplished as their different training results in a completely different outlook. While the engineer, accustomed to work by the clear and absolute laws of Nature is inclined to assume that other people's work must be equally stabilised, everything in economics depends on fluctuating relations between different classes of human beings. Even the medium of measurement, money, has a variable value; it is, so to speak, elastic, and is stretched or compressed according to the economic conditions. Moreover, most handbooks on accountancy and costing deal with their subject in rather a mechanical manner; perhaps explaining the work in detail, but doing so without examining the interconnection of the various steps to be taken. It is not surprising, therefore, that engineers seldom find any interest in the work of the accountant.

That these facts are well known and that authoritative circles are concerned to bring about a change for the better, is shown by the action of the leading engineering institutions in including the study of economics in their curricula for qualification; but there is still much more to be done, to demonstrate the principles of the accountants' side of economic control and the close association between the engineers' and the accountants' points of view.

OBITUARY.

DR. J. S. OWENS.

THE death of Dr. John Switzer Owens on December 6, closes a professional career of a somewhat unusual nature; for Dr. Owens' training was initially medical, and it was only at the age of 26 that he decided to abandon his medical career and take up engineering. He was born at Enniscorthy, Co. Wexford, on July 28, 1871, and entered Dublin University at the early age of 16; where, three years later, he was awarded a B.A. degree in experimental physics as the first stage in a medical course. He left the University in 1892 with the qualifications of B.A., M.D., B.Ch. and B.A.O., and embarked on his career as a doctor. It did not content him, however, and in 1897 he decided to follow his natural inclination towards engineering. After a short period of apprenticeship in pattern-making and foundry work in Gateshead-on-Tyne, he transferred to the works of the Wallsend Slipway and Engineering Company, where he was engaged for some 15 months on fitting and erecting marine engines. Meanwhile, he attended evening classes at the Durham College of Science and, at the end of two years' preliminary work, entered the office of the late Mr. E. Case, A.M.Inst.C.E., in Westminster. Mr. Case specialised in the design of sea defences and sewage-disposal works and, after five years of steadily increasing responsibility in this field, Dr. Owens took up private practice on his own account, acting, among other professional duties, as consultant to the East Sussex County Council for sea defence works. Gradually he extended his scope, designing plant for concrete-mixing, the drying of materials, and dredging. In 1912, he was appointed consulting engineer to the San Domingo mines, in Portugal, a connection which led eventually to a similar appointment in connection with the Rio Tinto copper mines, in Spain. For the latter undertaking, he designed much new plant and apparatus, including subaqueous drilling equipment, air-lift pumps,* and an alignment indicator for boreholes.†

Dr. Owens was technical adviser to the London Smoke Abatement Society and, for 18 years (1912-30) he was Superintendent of Observations on atmospheric pollution for the Department of Scientific and Industrial Research. Latterly, the problems of atmospheric pollution engaged an increasing amount of his attention, and he was responsible for the design of several instruments for their investigation. Many of his studies in this connection were the subject of papers before technical institutions, and were reprinted in our columns. He was also joint author, with Sir Napier Shaw, of a book on *The Smoke Problems of Great Cities*, published in 1926. Eighteen years earlier, he had collaborated with Mr. E. Case in a text-book on *Coast Erosion and Foreshore Protection*. Dr. Owens was an associate-member of the Institution of Civil Engineers, to which he was elected in 1902, and a member of the Institution of Mechanical Engineers.

INDUSTRY AND THE TECHNICAL PRESS.

IN the quality of its matter, the responsible character of its comment, and its editorial independence, the British technical Press has long stood without a serious rival anywhere else in the world; but most of those who direct its many specialised publications have probably been led to wonder, sometimes, whether its unique status in these respects is not in danger of being taken for granted by the great profession and industry that it serves, and even more by the executive heads of Government departments. It is particularly gratifying, therefore, to acknowledge the tribute that was paid to it recently by Mr. John Pascoe, deputy chairman of Messrs. British Timken, Limited, at a luncheon held in London to celebrate the 21st anniversary of the incorporation of that firm as a limited company, some nine years after the manufacture of Timken bearings was first undertaken in this country. Having reason to know that there are still some Press officers, both in the State departments and in industry, who apparently do not appreciate how different are the outlook, the functions, and the requirements of technical journals from those of the popular Press, we are glad to take the opportunity to quote Mr. Pascoe's remarks at some length; for, as an indication of the purposes and the present difficulties which ENGINEERING shares with its technical contemporaries, they could hardly be improved upon.

"The Timken bearing," said Mr. Pascoe, "has grown from small beginnings, to fame throughout the engineering world. Our task in achieving that progress has been due in large measure to the fact that Britain possesses a great technical Press. We saw its merit from the first, advertised in it, and gave every help we could to editors who wanted technical information. We have also been great readers of technical journals and have derived considerable benefit from that. Almost every one of our executives reads some specialised journal covering his own field. We encourage them to do this, and, in fact, should not think much of a key man who did not go to the obvious source of information about the latest development in his particular sphere. I would like to say how impressed I am by the way the technical Press is doing its important war-time job, amid difficult conditions of paper supply and manpower. The technical press is doing very real and vital services to industry. Its work is an essential part of the drive for higher production. It is an essential industry in itself.

"All executives know how valuable it is to get together with fellow technicians. Even in peace time, it is only possible for the larger industries to organise really representative conventions of men from all parts of the country; yet technical journals stage a conference of the industries they serve once a week, bi-monthly or monthly. They give us news of the latest results of research and the practical application of new production ideas. In articles, we are able to read the views of experts, to talk with whom many an industrialist would willingly journey the length of this country. They abstract the essential points from overseas journals and save industry an immense amount of time and trouble in so doing. They act as an exchange of information on welfare and other works management problems, which are always of great importance, but are vital in our war production drive. I am, as I have said, aware that the technical Press is fulfilling its functions despite difficulties. I only hope that those difficulties will not be aggravated.

"A technical journalist has to be doubly skilled. He has to be a good journalist, to start with—and a responsible one. Accuracy in his facts and precision in his language are worthy things with him. But he has also to develop a far-reaching knowledge of the industry his journal serves. He has to be able to meet the experts on their own grounds. He has to draw out the good they can give their industry. He is the key man of his industry's brain exchange. It would be most unfortunate lightly to take away for the Services these experienced men, practically all of whom are serving hundreds, and in some cases thousands, of firms fully engaged on essential production.

"I hope, also, that something can be done about the paper problems of the technical Press. Few people in this country do not realise how important it is to us to have unfettered newspapers. Technical journals are the newspapers of industry—one might put it more vitally and say, the newspapers of production. There is still too much paper used for publications which have very poor claims to service to the community, compared with those of the technical Press. There is no waste about the circulation of a technical journal. No one would buy a journal unless he were definitely interested in industry—and a particular industry at that. Further, each copy is nearly always read by more than one technician. Often a copy bought by a factory is read by a dozen executives, sometimes by many more. Taking our own case at the British Timken works, some journals are read by as many as 30 people. They are kept for more than a year, and are constantly referred to. Moreover, these journals are read by leaders of industry overseas, many of whom are men of great influence in their respective countries. It is important that we should maintain that fine standard for which our technical journals have long been known, and that we should present the picture of industry as it is—vigorous, efficient and 100 per cent. engaged in the war effort."

Mr. Percival Marshall, executive chairman of the Periodical, Trade Press and Weekly Newspaper Proprietors' Association, thanking Mr. Pascoe for his remarks, said that they were valuable in that they came, not from anyone personally interested in the technical Press, but from an industrialist, and a man known for his sound judgment and a long record of management of most successful enterprises. As Mr. Pascoe said, technical journals played an important part in picturing overseas the great effort that industry here was making. They went to the key men overseas; it was most important that those men should be confident that we were doing our best.

* See ENGINEERING, vol. 112, page 458 (1923).

† *Ibid.*, vol. 121, page 87 (1926).

THE TREATMEAT OF TIMBER IN A DRYING-KILN.*

(Concluded from page 418.)

The Application of Equilibrium Conditions.—When the timber as a whole is nearly dry, samples will almost invariably indicate that the moisture content of some boards in the pile has been sufficiently reduced, other boards requiring further drying. If the air circulation has not been reversed, those samples situated on the air-outlet side of the pile will almost certainly be wetter than those on the air-inlet side, and even if the circulation has been reversed it is probable that samples situated half-way across the pile may still require further drying when the others have the desired moisture content. At this stage a uniform degree of dryness can only be secured by abandoning the schedule and applying special so-called equilibrium conditions, for if the conditions laid down in the schedule were continued, some of the timber would become over-dried. The method of ensuring that timber in all parts of the stack is dried to a more or less uniform state of moisture content is to apply such conditions of temperature and humidity as will eventually bring all the timber into equilibrium at the same moisture content.

Table I gives the relation between wet-bulb hygrometer readings and equilibrium moisture contents of wood at various air temperatures in a drying kiln. The values are approximate only, but are applicable to most of the common commercial timbers. It is used as follows: Suppose a final moisture content of about 12 per cent. is desired and the kiln is operating at 140 deg. F. (60 deg. C.) dry-bulb temperature, and 115 deg. F. (46·1 deg. C.) wet-bulb temperature, *i.e.*, 45 per cent. humidity, reference to the table will show that these conditions correspond to an equilibrium moisture content of about 7½ per cent. If these conditions were left undisturbed after some of the samples had dried to the desired moisture content, further drying would occur, these samples tending to dry down to a final value of 7½ per cent. In order to prevent this, but to continue with the drying of pieces containing a moisture content higher than 12 per cent., it is apparent from the table that the wet bulb must be raised to 128 deg. F. (53·5 deg. C.), *i.e.*, the humidity must be raised to 70 per cent. At this higher humidity the drying rate will fall and the wetter pieces will take longer to dry to about 12 per cent. than if equilibrium conditions had not been applied. Such a final conditioning treatment at a fairly high humidity is always beneficial, as it tends to promote a more uniform distribution of moisture throughout the cross-section of each piece in the load. Moisture distribution tests carried out on the lines indicated in *Forest Products Research Leaflet No.* 7 should always be made to check the condition of the timber just before the conclusion of the run if the thickness of material permits.

TABLE I.

Dry Bulb (Deg. F.)	Wet Bulb (Deg. F.)								
95	72	74	77	79	81	83	84	85	86
100	76	78	81	83	85	87	89	90	92
105	80	82	86	88	90	92	94	95	97
110	84	87	91	93	95	97	99	100	102
115	89	92	96	98	100	102	104	105	107
120	93	97	101	103	105	107	109	111	112
125	98	102	106	108	110	112	114	116	117
130	103	107	111	113	115	117	119	121	122
135	108	112	116	118	120	122	124	126	127
140	113	117	121	124	126	128	130	132	133
145	118	122	126	129	131	133	135	137	138
150	123	127	131	134	136	139	140	142	143
155	128	132	136	139	141	144	145	147	148
160	133	137	141	144	147	149	150	152	153
165	138	142	146	150	153	155	156	157	158
170	143	147	151	155	158	160	161	162	163
175	148	153	156	160	163	165	166	167	168
180	154	159	162	166	168	170	171	172	174
185	160	165	168	171	174	176	177	178	179
190	166	171	174	176	179	181	182	183	184
195	171	176	180	182	185	187	188	189	190
Moisture content per cent.	7	8	9	10	11	12	13	14	15

Case-Hardening and Its Relief.—The most serious forms of trouble experienced during the drying of a load of timber are caused most often by drying stresses, which, if excessive, produce case-hardening, checking, honeycombing and many other evils. Rapid drying from the surface of a board in a kiln will eventually tend to cause the surface layers to shrink in excess of the interior, with the result that stresses are set up which first induce compressive and tensile strains in the various portions of the section and may eventually cause the timber to check or split on the surface. Even if splitting does not occur, these drying stresses may cause "case-hardening"—a serious defect when the timber has to be re-sawn or machined. Tests for such stresses may be made at any stage of the drying, by sawing short cross-sections of the sample boards. For instance, to test for the presence of stresses in 2-in. material, cross-sections ½ in. thick should be cut 9 in. or more from one end and these sections cut into four equal strips parallel to what were originally the surfaces of the boards. Alternatively, prongs may be made in the piece of 2-in. material by cutting out the centre portion to within an inch or so of one end, so that the sample resembles a tuning fork without a handle.

During the early stages of drying, tension stresses are usually set up on the outer portion of the cross-section, and case-hardening prongs or strips newly cut from wood in this condition curve outwards. In order to judge the ultimate effect of the stresses on the finished material, it is necessary to allow these case-hardening samples to dry for a time, say, 12 hours to 24 hours, in a room to a uniform moisture content. The slightly wetter inner faces of the prongs will then shrink more than the outer faces, and when equilibrium is reached it will be found that if the timber is case-hardening the curvature is altered and both prongs will bend inwards. As the load of timber continues to dry, the distribution of stress across the section is reversed, the core being in tension and the outer shell in compression. Case-hardening samples cut from wood in this condition will immediately curve inwards, the curvature being further increased by room drying. The method of relieving case-hardening is to moisten the outer surface of the timber so that it tends to expand around the core but is prevented; this induces a strain opposite to and neutralising that produced previously by normal shrinkage stress during drying. This relief treatment may be carried out by raising the humidity for short periods of, say, from 2 hours to 6 hours, to 90 per cent. and at the same time raise the temperature some 20 deg. F. above that at which the kiln is running at the time. Should, however, the kiln be running at a temperature in the region of 180 deg. F., it will not generally be found necessary to raise the temperature further. The conditioning treatment referred to earlier in many instances will be found to be sufficient for the purpose of relieving case-hardening stresses.

Warming and Cooling a Kiln.—In warming a kiln the temperature of the wood will lag appreciably behind that of the air and the humidity of the air as it passes between the rows of timber will be appreciably increased. If the warming is done reasonably fast, moisture may be condensed on the surfaces of the timber and the moisture content even of green timber is increased slightly as a result. For this reason it is better not to subject the wood to a steaming treatment or to high humidities during this initial warming period. As a guide a constant difference between wet- and dry-bulb reading of 9 deg. F. (5 deg. C.) should be maintained until the desired dry-bulb temperature is attained, when the wet-bulb reading is set to correspond with the schedule to be adopted. In cooling the dried wood, it is often possible to subject it immediately to atmospheric conditions, but such a practice cannot generally be recommended. The timber will retain its heat for some considerable time and the cooler air that enters between the rows will become hotter and drier as a consequence. This may lead to a renewal of case-hardening stresses and may even cause splitting. Theoretically, the air humidities should be kept high during this cooling period, but to reduce the cooling time it is suggested that, again, a difference of 9 deg. F. should be maintained until a temperature of, say, 80 deg. F., is reached, when the timber can be subjected to atmospheric conditions with impunity.

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NOTES FROM NORTH AMERICA.

The extent of the United States defence programme can be judged from the fact that, during the first nine months of 1941, the construction work started totalled 4,844 million dols., more than for any twelve-month period in the past. In 1929, a record for new industrial buildings was established, when 550 million dols. worth of contracts were awarded. However, similar work begun in 1940 soared to 929 million dols., including 335 million dols. of factory construction financed by the Federal Government; and, in the first nine months of 1941, the industrial building total was 1,517 million dols. Industrial building for the entire year 1941 is expected to reach 2,000 million dols., or four times the total of 1929. This huge programme is having a great effect upon the availability of building and manufacturing materials, and about 300 items are now listed on the priorities list prepared by the Office of Production Management. Many of the items are subject to priority regulation only in the sense that Army and Navy orders may be assigned preference ratings for early deliveries, but numerous other materials, plentiful in peace time, are now not to be had for other than defence work. For example, the use of copper has been prohibited for building construction. Although sufficient copper is now available to meet all needs allowed, in 1942 a shortage of 750,000 tons is expected. Lead is another material added to the priorities list during October. It is still plentiful, but shortages are expected later, and putting lead on the critical list is expected to cause curtailment of much present civilian consumption.

A survey by the American Bureau of Shipping shows that, if the 1941 shipbuilding programme planned by the Maritime Commission is carried out, 134 ships totalling one million gross tons will have been built in the United States during the year. In 1940, 53 ships totalling 444,703 tons were constructed; while, in 1939, 28 ships, of 241,052 gross tons were built. During the three years 1914 to 1916, inclusive, United States yards completed 116 vessels totalling 605,888 tons. Thus, American shipbuilding during 1939-41 will be nearly three times as much as in 1914-16. The Maritime Commission intends to put into operation 1,153 new ships between July 1, 1941, and December 31, 1943.

The construction of 150 to 200 wooden cargo ships at Vancouver, British Columbia, is proposed in a plan submitted to the Canadian Government at Ottawa by the Star Shipyard (Mercers), Limited, New Westminster, B.C., and Vancouver Shipyard, Coal Harbor, B.C., two leading firms of boat builders. Thirteen other Greater Vancouver and Royal City wooden-boat builders are ready to co-operate. This is the first time that wooden shipbuilders in the area have organised in a united effort to construct wooden freighters. The plan is to build ships of 3,000 deadweight tons to supplement Canada's already large steel cargo-ship programme. It is suggested that the wooden ships can be built in existing yards in Burrard Inlet, Coal Harbor, in False Creek and on the Fraser River. These yards, which until now have been building seiners, ferry boats, tugs and small craft for the armed Forces, will have to be enlarged to turn out 3,000-ton vessels. In addition, new yards for the construction or wooden ships can be established at comparatively low cost on half a dozen sites in the same districts. Another shipbuilding proposal, designed to relieve the oil shortage in the eastern States, is that of the Maritime Commission, to build 15 reinforced-concrete ocean-going oil-tank barges. The order will be divided evenly among three shipyards, on the Atlantic Coast, the Pacific Coast, and the Gulf Coast, respectively. Specifications call for a barge not more than 360 ft. long, with a draught when fully loaded of not over 28 ft. 6 in.; cargo capacities range from 5,000 tons to 8,000 tons. If the 15 barges are successful, a large number of similar vessels will be constructed.

America's defence effort is placing a heavy burden upon American railroads and other inland transportation facilities. October was expected to be a period of peak traffic for the railways, but no severe shortage of railroad cars developed, as about 1,728,000 cars were required and 1,792,000 active cars were available. That the railroads of the United States have been preparing for the present heavy traffic and still greater demands in the future is shown by the fact that during the first nine months of 1941, some 108,963 freight cars, 1,013 locomotives (including 686 Diesel-electric locomotives) and 621 passenger cars were ordered. This compares with 38,665 freight cars, 501 locomotives, and 217 passenger cars ordered during the same period in 1940. Railroad equipment manufacturers (not including railroad-owned shops) had 65,230 freight cars on order at the end of September, 1941, compared with 20,746 a year ago. Inquiries for future orders include 250 locomotives wanted by the United States War Department, 25 locomotives for the Yunnan-Burma Railway in China, and 2,860 freight cars for the Egyptian State Railways.

Three well-known American engineers died during October. Charles Lorenzo Clarke, formerly chief engineer of the Edison Electric Light Company, and for many years associated with Edison himself, died at Newton, Massachusetts, on October 9. He superintended the construction of the first large central lighting station built in the United States, at Pearl-street, in New York City, in 1882. Mr. Clarke joined the staff of the General Electric Company, Schenectady, New York, in 1913, and served them successively as consulting engineer and research specialist until his retirement in 1936. Ford R. Lamb, executive secretary and past-president of the American Society of Tool Engineers, died at Pinckney, Michigan, on October 26, at the age of 50. After inventing a "stud setter" in 1928, Mr. Lamb took his invention to the Consolidated Machine Tool Corporation with whom he remained as sales engineer until 1937. In 1932, the American Society of Tool Engineers was founded, with Mr. Lamb as one of the first directors. In 1936, he was elected the society's fifth president. When his term of office expired in 1937, the society offered him a new post as executive secretary. Mr. Lamb resigned his position with the Consolidated Machine Tool Corporation and gave all his time to his new work. Under his guidance the society grew to a total of over 8,000 members. Henry Buker, vice-president of the Brown and Sharpe Manufacturing Company, with which he was associated continuously for 49 years, died on September 29, at Providence, Rhode Island. He was 68 years of age. For many years he had been one of the leaders of the American machine-tool industry, and had been president of the National Machine Tool Builders' Association.

Reaching their highest monthly value since January of this year, United States exports of industrial machinery in August was valued at 41,976,614 dols., an increase of more than 50 per cent. over the July figure. It was reported by the United States Department of Commerce Exports that exports of machine tools, which for the past three months have shown reduced shipments, registered a sharp recovery in August to 17,124,342 dols., a gain of more than 85 per cent. over the July total. Increases were recorded in all classes of machine tools in August over those of July. Milling machines showed the largest gain, increasing from 2,034,603 dols. to 4,151,690 dols. Exports of lathes advanced from 1,730,327 dols. to 3,544,183 dols., drilling machines from 528,764 dols. to 1,629,846 dols., and foreign sales of grinding machines rose to 2,399,030 dols. from 1,168,936 dols. Metal-working machinery other than machine tools also showed increased exports in August, amounting to 3,574,584 dols., compared with 2,279,740 dols in July. Shipments of rolling-mill equipment totalled 543,558 dols. in August, as against 456,542 dols. in July; forging machinery increased to 979,475 dols. from 719,161 dols.; while sheet and plate metal-working machinery registered the largest gain, increasing from 650,128 dols. to 1,558,422 dols.

On October 4, the first of the 108,000-kW generators at Grand Coulee Dam, on the Columbia River, was put into operation. A second unit of the same size is expected to be put into service in January, 1942, and the third unit, some time later in 1942. These are the first of the 18 generators that will ultimately be installed in the two power-houses of the dam. Some time ago, two 10,000-kW units were put into service. Another of these smaller generators will also be installed, making the total capacity of all generators 1,974,000 kW. Another interesting hydro-electric unit to be put into service during October was the 27,000-kW set at Glenville Dam, on the Tuckasegee River, a tributary of the Little Tennessee River, North Carolina. This unit has a double impulse wheel rated at 30,000 h.p., and operates under a 1,215-ft. gross head, the highest head for any American impulse wheel of its type. Two 10-in. diameter jets direct a maximum discharge of 270 cusecs on to the wheel. The 1,215-ft. head also makes Glenville Dam the highest-head hydro-electric plant in the eastern States. Glenville Dam was built by the Aluminium Company of America, and is a 150-ft. high earth-fill dam, faced with rock. A total of 1,300,000 cub. yds. of material was required, and the storage will be 68,000 acre-ft. of water.

Now under construction as part of the Fort Loudon Dam scheme on a tributary of the Tennessee River, near Knoxville, Tennessee, is a navigation lock, believed to have the highest single lift in the world. The lift is 80 ft. and the lock chamber measures 60 ft. by 360 ft. in plan. The lift exceeds by 5 ft. the lift of the new lock at the Pinopolis Dam, which is a part of the Santee-Cooper project in South Carolina. Fort Loudon Dam is being built by the Tennessee Valley Authority.

THE TRANSVAAL GOLD-MINING INDUSTRY.—The output of gold from the Transvaal in October totalled 1,235,784 fine oz., as compared with 1,211,277 fine oz. in October, 1940. The output for October, 1941, constitutes a record which is 10,012 oz. above the previous highest total recorded in July, 1941.

LABOUR NOTES.

IN the industries for which statistics are regularly compiled by the Ministry of Labour and National Service the changes in rates of wages reported to have come into operation in October resulted in an aggregate increase estimated at about 60,000*l.* in the weekly full-time wages of about 430,000 workpeople, and in a decrease estimated at about 1,000*l.* in those of 67,000 workpeople. The workpeople whose rates of wages were reduced had received increases of greater amount during earlier months of the year. Of the estimated total increase of 60,000*l.* a week about 100*l.* was due to the operation of sliding scales, based on fluctuations in the proceeds of the coal-mining industry; 50,000*l.* to arrangements made by joint standing bodies, including 4,500*l.* under cost-of-living sliding scales arranged by such bodies; 1,200*l.* to the operation of other sliding scales based on the cost of living, and 100*l.* to arbitration awards. The remaining 8,100*l.* was the result of direct negotiations between the employers and workpeople or their representatives. Nearly all the estimated decrease of 1,000*l.* was due to the operation of sliding scales based on fluctuations in the proceeds of the coal-mining industry.

The changes reported in the first ten months of 1941 in the industries covered by the statistics, are estimated to have resulted in a net increase of about 1,600,000*l.* a week in the full-time wages of nearly 7,600,000 workpeople. In the corresponding ten months of 1940 there was a net increase in these industries estimated at about 1,900,000*l.* in the weekly full-time wages of approximately 7,800,000 workpeople.

The number of trade disputes involving stoppages of work, reported to the Ministry, as beginning in October was 145. In addition, 11 disputes which began before October were still in progress at the beginning of that month. The approximate number of workpeople involved in these 156 disputes (including employees thrown out of work at the establishments where the disputes occurred) was 35,000, and the aggregate duration of the disputes in October was about 96,000 working days. The great majority of the disputes involved only small numbers of workpeople and about two-thirds of the stoppages lasted only one or two days.

An interesting analysis of the wage-earnings of six million employees carried out by the Ministry of Labour and National Service is given in the November issue of *The Ministry of Labour Gazette*. Average earnings during the week ended July 12, 1941, showed, it is stated, an increase of 42 per cent. compared with the last week of October, 1938, and were about 9 per cent. higher than in July, 1940. Average weekly earnings in July, 1941, were 75*s.* 5*d.* for all employees. Men averaged 99*s.* 3*d.*, youths and boys under 21, 40*s.* 7*d.*, women over 18, 44*s.* 4*d.*, and girls under 18, 25*s.* 2*d.* Percentage increases over October, 1938, for the same groups were for men 43 per cent.; youths and boys, 57 per cent.; women 36 per cent.; and girls 35 per cent.

The largest percentage increases compared with October, 1938, were in the metal, engineering and shipbuilding industries. The average for the whole group rose by 49·2 per cent. in this period. Shipbuilding and ship-repairing showed the largest individual increase of any trade included in the census—73 per cent. Marine engineering, hand tools, and the other metal industries groups all rose by over 50 per cent., and there were increases of over 40 per cent. in non-ferrous metals; iron and steel tubes; general engineering; iron and steel founding; electrical engineering; structural engineering; motor and aircraft manufacture and repair; bolts, nuts and screws; and brass and yellow metal goods. The average wages for trades in this group included: motor and aircraft manufacture and repair, 104*s.* 7*d.*; shipbuilding, ship-repairing and pig-iron manufacture, 103*s.* 8*d.*; steel smelting and rolling and iron puddling, 101*s.* 10*d.* Motor and aircraft manufacture also showed the highest individual wage for men over 21, namely, 127*s.* 5*d.*

Reviewing the activities of the trade union movement in 1941, Mr. Arthur Deakin, the acting general secretary of the Transport and General Workers' Union, says that he personally regards the Essential Work (General Provisions) Order along with the Rehabilitation Scheme of the Ministry of Labour and National Service as amongst the most far-reaching changes within the industrial structure. The first, he continues, provides a guarantee of 52 weeks' work with wages based upon a normal week's pay, and the second establishes the principle of refitting disabled men both from the Fighting Forces and industry and gives them an opportunity to train, without cost, in an occupation suitable to their capacity. Both provisions, he claims, "reflect the experience of the Minister of Labour and National Service in the trade union field."

In respect of wages, Mr. Deakin goes on to say, "progress has been very considerable in many industries where wage negotiating machinery was conspicuous by its absence in the days immediately before the war. This has been eliminated to the extent that it is now not too much to say that probably 90 per cent. of the industrial workers have their wages and conditions of employment fixed by some form of joint organisation in which the representation of the workers' interests is undertaken by the trade unions."

The claim of the Engineering Joint Trades Movement for a wage increase of 1*l.* a week on basic rates was heard by the National Arbitration Tribunal on Friday last week. The Joint Trades Movement is comprised of the engineering unions belonging to the Confederation of Shipbuilding and Engineering Trades and does not include the Amalgamated Engineering Union or the National Union of Foundry Workers. The Movement's case was presented by Mr. Mark Hodgson, general secretary of the Boilermakers' and Iron and Steel Shipbuilders' Society, who said that, in years of depression, the workpeople suffered extensive reduction which were justified, the employers claimed, by the state of the engineering industry at the time. Now, with the full capacity of the industry employed, the employers refused to discuss the question of wages on the same basis. Before the war, basic rates were exceptionally low compared with those in other industries.

Sir Alexander Ramsay, director of the Engineering and Allied Employers' National Federation, in replying, submitted that the application should be regarded by the Tribunal in the light of the general wage position. All industrial workers would demand whatever was conceded to engineering workers. He quoted earnings, including figures given in the survey, carried out by the Ministry of Labour and National Service and summarised above, which show that in one week in July the average earnings of men in the industry were 5*l.* 11*s.* 5*d.* a week. Mr. Hodgson argued that the figures cited included a great deal of overtime worked under the urge of national necessity. It was unfair, he said, to ask the workers to build every possible tank, gun, plane and ship by working abnormally long hours and then to use their earnings against them.

The claim of the Amalgamated Engineering Union and the National Union of Foundry Workers for an advance on the basic wage rate of 4*d.* an hour, or 15*s.* 8*d.* a week, was argued by Mr. J. Tanner, President of the A.E.U., before the National Arbitration Tribunal last Monday. He stated that the wage rates of fitters and turners, in many districts, were below 4*l.* a week, and time workers were obliged to depend on excessive overtime to meet the present costs of living. In reply, Sir Alexander Ramsay refuted the argument that the employers were getting excessive profits out of the war, in which the employees were not sharing. He stated once again that over the whole range of the engineering, shipbuilding, and metal-industries group, the average weekly wage, in July, was 5*l.* 11*s.* 5*d.* and that in motor and aircraft manufacture the weekly wage ranged up to 6*l.* 7*s.* 5*d.* The award of the tribunal will be issued in due course.

In answer to a question in the House of Commons on Thursday last week, the Minister of Labour and National Service said that he had received the report of the Beveridge Committee on the use of skilled men in the forces, but could not yet make a statement on its contents. Questions affecting defence and the organisation of Services were involved, he added, and the report quite properly was being considered by the Defence Committee. Therefore, although the report was made to his department the matters raised had first to be considered by the Prime Minister.

Mr. Bevin said he must have notice of the question when asked by a member if he would take power to control the rate of juvenile wages above a reasonable amount. Replying to another question, he disclosed that when he found that in certain limited spheres, such as building and civil engineering, excessive payments had been made, he immediately took the matter up. The industry had now established a proper scale for youths and he thought that in the section of the trade where the trouble arose it had largely been corrected.

A CENTURY OF TUNNELLING.*

By W. T. Halcrow, M.I.Mech.E.

(*Continued from page* 460.)

For the erection of the cast-iron segments of the lining, an erector arm is frequently attached to the back of the shield. In certain soils, a mechanical excavator is used and this is embodied as an integral part of the shield. The modern tendency is to make the shield as simple as possible, and to design it to suit the particular class of soil in which it is to be used. Shields may be divided into two main types:—(*a*) the simple shield, with several variations or additions, (i) with open face, or (ii) with diaphragm having single or multiple doors; and (*b*) the rotary shield, which is a shield combined with a rotary excavator. To either type, the mechanical erector can be attached as an integral part. Figs. 11 and 12, on this page, show a diagram of a modern shield of type (*a*) for a 12-ft. 3-in. diameter tunnel. It is furnished with ten rams and has a total weight of 20 tons. The diameter of the rams is 7 in., and the total maximum thrust, 385 tons. Figs. 13 and 14 show a rotary shield of type (*b*) for a tunnel of the same size. It has 12 rams, and its total weight is 46 tons.

As examples of large shields, the shields for the London tube station tunnels, of 21 ft. 2½ in. internal diameter, have a weight of 80 tons, and carry 22 rams 7 in. in diameter, giving a maximum thrust of 847 tons. The 30-ft. 8-in. diameter shields used for the Rotherhithe road tunnel (1908) were fitted with 40 rams, 9 in. in diameter, two erectors, and three sets of sliding platforms. The weight was 290 tons, and, where a hood extension was added, it was 342 tons. The total maximum thrust exerted by the rams was 8,500 tons.

In soft silt or mud, the shield can be driven forward without any excavation, the soil being partly compressed and partly extruded through the openings in the diaphragm. In such soil, a shield of type (*a*) is used with a diaphragm. A small door at the top of the latter allows the mud to pass out on to a chute, the lower end of which is attached to a movable bulkhead or dam which keeps the silt clear of the back of the shield. In soft clay, a similar shield is used, but the clay, as it is extruded through the door, is cut off in slabs with a knife. In dry clay or harder material, excavation is necessary. This can be done by hand, using a shield of type (*a*), or mechanically, using one of type (*b*). The hand excavation can be aided with such devices as pneumatic picks, spades, and power knives, as best suited to the particular soil. In sand or other material which requires excavation, but which at the same time has to be timbered up, hand excavation is employed with a shield of type (*a*), one with face jacks being preferable. If the perimeter of the tunnel in front of the shield has to be timbered, the timbering is kept wide of the tunnel and is left in as the shield advances. In open water-bearing gravel, compressed air is used to keep back the water. A simple hooded shield is generally used. The difficulty is to prevent loss of air.

An interesting modification, introduced by the late Sir Harley H. Dalrymple-Hay, to the face timbering in shield tunnelling under compressed air, is the replacement of the poling boards round the cutting edge by tempered clay. A series of pockets are scooped out and refilled with clay, starting from the top and working downwards; these pockets project slightly beyond the circumference of the shield. As the shield is moved forwards, the cutting edge becomes embedded in an annular ring of clay which acts as a seal preventing the escape of air. This device has been found to effect a considerable economy in compressed air.

The use of a hooded shield also helps to reduce or eliminate the timbering. The hood forms an integral part of the shield and is an extension of the upper part of some 2 ft. beyond the lower cutting edge. The whole face is sometimes covered with clay and straw behind the face boards to reduce air leakage. In mixed ground, where the top is soft and the bottom in rock or material hard enough to require blasting, a simple hooded shield is used. In some cases where the rock runs level, a half-shield or roof shield is used.

There are several types of mechanical excavator which have been specially designed for use with shields. The earliest was the Price excavator, employed in 1897 on the Central London Railway. It consists of six radial arms attached to a central shaft on the shield, each carrying a knife spaced at different distances from the centre. The apparatus is revolved about the shaft, when the knives, supplemented by a triangular toothed cutting plate at the centre, break down the face. Each radial arm carries a bucket which collects the spoil excavated by the knife and tips it into a chute as the arm reaches its uppermost position (Figs. 15 and 16, opposite). Another type of excavator is the Carpenter excavator, comprising a horizontal shaft carrying a boring tool and an arm at right-angles to it. The arm itself forms the support for a cutting tool, which moves automatically to and fro along it as the shaft revolves. The boring tool cuts a central hole while the cutting tool strips the face. A third type is the Anderson excavator, in which a revolving knife makes a light cut over the whole face at each revolution, which is accompanied by an automatic forward feed.

As already indicated, cast-iron lining is most commonly adopted in tunnels driven with a shield. The lining consists of a number of segmental pieces which are bolted together to form a complete ring, generally 18 in. to 30 in. in width, according to the diameter of the tunnel. Each ring is built up, the separate segments being bolted to each other and to the preceding ring. Joints are made watertight by caulking with a rust joint or with lead, the former method being, however, inapplicable if water is present, unless a preliminary caulking with lead wire is first made. The bolt holes are made tight by a lead washer or by a grummet of hemp soaked in red lead and oil and placed under the washer. After completing each ring, the space left behind it when the shield is moved forward is grouted up with lime or cement grout under pressure. Where large voids occur, a method recently adopted for filling the space, which saves cement, is to blow in fine round gravel, passing a ¼-in. ring, by means of compressed air through grouting holes, and this mass is then grouted up.

The advantages of cast-iron lining are:—(1) no shuttering or centring is required; and (2) each ring is ready, on completion, to take the thrust of the hydraulic jacks without loss of time. A mechanical erector is generally used to place the heavy cast-iron segments in position. It consists essentially of an arm, at the back of the shield, rotating about the centre. The segment is supported by the arm, which is then turned to the required position. The first use of this appliance was in the Sarnia tunnel, in 1888, the erector being attached to the shield and operated by hand. A hydraulically-operated erector, separate from the shield, was used on the Hudson River tunnel in 1889, and twin hydraulic erectors, coupled to the shields, were employed on the Blackwall tunnel in 1892. Modern practice favours one or more hydraulic erectors coupled to the shield for tunnels of large diameter. In small tunnels, up to 12 ft. in diameter, the comparatively light segments are erected by hand. The cast-iron lining of road tunnels is generally supplemented by an internal concrete lining.

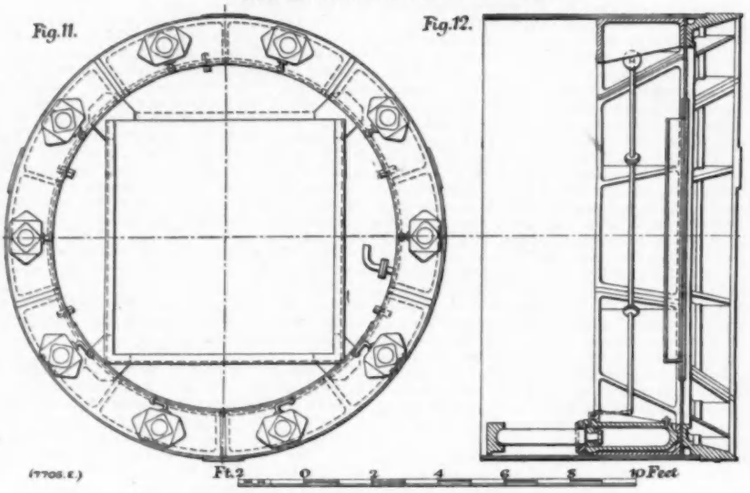
Of materials other than cast iron, rolled steel has been used, and presents advantages over cast iron in respect of greater tensile strength and reduced weight. Timber lining has been used to some extent in the United States. Brickwork and masonry have generally given way to concrete. Concrete cast *in situ* has the disadvantage that, until it has set, it is unable to carry the thrust of the jacks, which has accordingly to be transferred to the shuttering, which must be made sufficiently strong for the purpose. Concrete in the form of keyed precast blocks (Fig. 17, opposite) is now sometimes used for lining. These can support the thrust of the jacks, and they have been found to lend themselves to a high rate of progress. When precast blocks are used, an internal lining of monolithic concrete is, on occasions, subsequently added. A combination of steel joists and concrete was used on the land tunnels of the Mersey tunnel.

Brunel's tunnel beneath the Thames is famous in several respects, and may be regarded as one of the milestones in the progress of tunnelling. It was not only the first tunnel to be bored beneath a river, but it was also the first occasion on which the shield, an

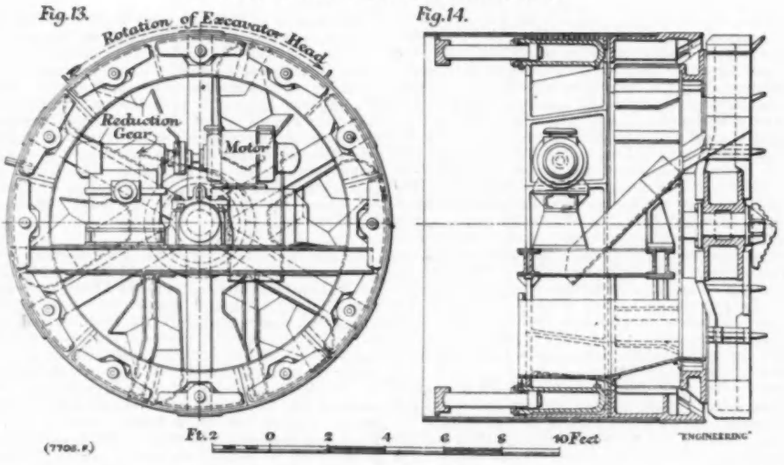
* The 28th Thomas Hawksley Lecture, read before the Institution of Mechanical Engineers, London, S.W.1, on Friday, November 21, 1941. Abridged.

A CENTURY OF TUNNELLING.

SIMPLE SHIELD FOR 12'.3" DIA. TUNNEL



ROTARY SHIELD FOR 12'.3" DIA. TUNNEL



A CENTURY OF TUNNELLING.

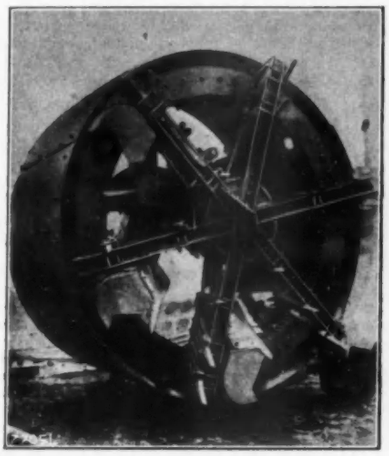


FIG. 15.

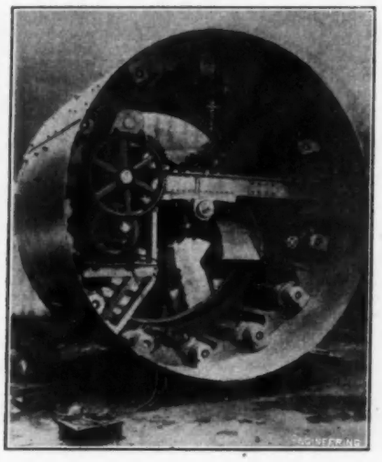


FIG. 16.

FIGS. 15 AND 16. SHIELD WITH ROTARY EXCAVATOR.

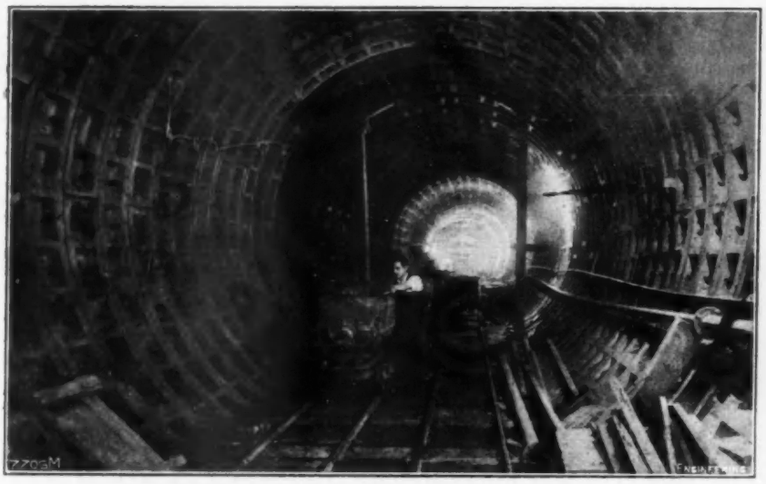


FIG. 17. TUNNEL SHELTERS WITH REINFORCED-CONCRETE SEGMENT LINING.

appliance specially devised by him for this work, was used. The tunnel was at that time a work of outstanding difficulty, and its ultimate carrying to successful completion was a remarkable achievement. The methods adopted may be rightly described as revolutionary, and, indeed, Brunel's great pioneer work blazed the trail which has led to the modern system of sub-aqueous tunnelling. It was unfortunate that his new methods should have been employed in the first case on so difficult a job, as the troubles he encountered undoubtedly made engineers shy of following up his ideas for some years to come. The tunnel was a large one, being rectangular in section and 37½ ft. in width by 22½ ft. in height. Commenced in 1825, it was not finally completed till 1843; but, for seven years of this long period, the work was closed down owing to lack of funds. The main difficulty arose from water, and though the use of compressed air was apparently suggested, it was not tried and no special measures were adopted to prevent blows; on several occasions the river broke through and flooded the tunnel. After this work, the shield was not used again until 1869, in which year it was applied to two small tunnels, one in London and one in New York.

Constructed in 1869, the Tower Subway tunnel was a small tunnel, 7 ft. 1¼ in. in diameter and 1,350 ft. in length, carrying a footway beneath the Thames through non-waterbearing clay. Under present-day conditions, it would not be regarded as presenting any special engineering difficulties. It is notable as being the first tunnel constructed with the help of a shield in what was practically its modern form, though screw jacks were used in place of the modern hydraulic jacks. The work was carried out by James Greathead, who subsequently devoted his life to shield tunnelling and whose name will always be associated with the development of the modern shield. In the Tower Subway tunnel, he was fortunate in meeting none of the difficulties from water which Brunel experienced. The successful completion of this work and of the Broadway tunnel, referred to below, undoubtedly went far towards restoring confidence, and a number of similar tunnels soon followed.

Constructed at the same time as the Tower Subway, the Broadway Tunnel, New York, was a small tunnel for an air-driven railway under Broadway, and was driven through dry sandy ground with the aid of an 8-ft. diameter shield. It shares with the Tower Subway the credit of being the first tunnel using a shield in its modern form, and it is also noteworthy as being the first occasion on which hydraulic jacks were applied to the shield. Following the successful completion of these two tunnels, the shield was also successfully used in a number of others, all in water-bearing strata, and it was not until 1879 that it was once more tried in subaqueous tunnelling, in the important Hudson River tunnel, and in a small tunnel under the Antwerp Docks. These two tunnels mark the first occasions on which compressed air was used to restrain the water, and cast-iron lining was employed.

In 1886, the City and South London Railway was commenced; it had a length of 6 miles and an external diameter of tunnel of 11 ft. 3 in. The shield was used throughout, and cast-iron lining was employed. The work was carried out by Greathead, who designed and used for the first time his apparatus for grouting behind the lining. The greater part of the tunnel was driven through impervious clay, but short lengths of water-bearing strata were encountered, in which compressed air was used in conjunction with the shield.

In 1892, the Blackwall tunnel under the Thames was successfully driven with the aid of a shield. This had the large section of 27 ft. diameter, which, however, was considerably smaller than Brunel's tunnel and serves to emphasise the magnitude of the task undertaken by him. Both tunnels come more appropriately under the classification of subaqueous tunnels. With the completion of the Blackwall tunnel, the use of the shield with or without compressed air may be regarded as being fully established as a safe and satisfactory method of tunnelling in bad ground, and in subaqueous work.

In shield tunnelling, conditions vary so greatly that it is difficult to give any general figures regarding rate of progress. Tunnels through London clay, mostly under 13 ft. in diameter, have shown an average rate of progress of 85 ft. a week with hand excavation, and of 165 ft. a week with mechanical excavation. With larger tunnels, and in water-bearing ground, the rate in most cases is slower. The record for tunnelling with a shield and compressed air was established in 1937, on the Detroit sewer tunnel, using a 22-ft. diameter shield; the soil was soft clay. The lining was made of precast interlocking concrete blocks 18 in. thick and 30 in. wide, and was later supplemented by an internal lining of concrete deposited *in situ*. An average advance of 50 ft. a day or, say, 275 ft. a week, was maintained. Before this, the record was held by the Lincoln Roadway tunnel, New York, with an external diameter of 31 ft. The rate of advance was 40 ft. a day or, say, 220 ft. a week. Though this tunnel was larger than the Detroit tunnel, there was actually less spoil to dispose of, as only 20 per cent. of the volume displaced passed through the shield.

(*d*) *Subaqueous Tunnels.*—By subaqueous tunnels, I refer to those driven under rivers, harbours, or estuaries. If there is a considerable depth of cover and the soil is impermeable, as in the case of the Tower Subway, then little difficulty occurs; but with permeable soil and thin cover, the case is very different. The first subaqueous tunnel to be constructed was Brunel's Thames tunnel, already referred to, and here the conditions were particularly unfavourable. His experiences give a measure of the troubles that may be encountered in the absence of adequate provision to hold back the water. In tunnelling under a river where there is only a thin cover through which the water is liable to leak, or even to break through, the inflow can be checked to a considerable extent by depositing a thick blanket of clay in the river bed. This was done on the Thames tunnel, the Hudson River, and several later tunnels. The lining is in all cases brought close up behind the excavation to reduce the area for leakage.

The most satisfactory method yet found of restraining the water is the use of compressed air. The difficulty lies in maintaining the pressure when the soil is porous and the cover slight. For subaqueous tunnelling under such conditions, the use of a shield and compressed air is now the recognised standard practice. In some cases, it may be found possible to lower the level of the tunnel and get into impermeable soil, but often the permeable soil extends to such a depth that this is impracticable, and the tunnel has to be kept at some higher level at which the air pressure required to restrain the water will not exceed the accepted safe limit. This, in turn, reduces the cover and increases the risk of blows. The clay blanket then becomes very effective; indeed, some tunnels have been constructed which, without its use, it is considered, would have been impracticable. Clay plugging of the face, as already described, is also another valuable device for reducing air loss. Chemical consolidation and grouting of the face have occasionally proved useful adjuncts in subaqueous tunnelling with compressed air.

Following the completion of the Tower Subway and Broadway tunnels in 1869, the shield was successfully applied to a number of tunnels in non-water-bearing soil, but it was not until 1879 that it was tried in subaqueous tunnelling for the first time since the Brunel tunnel. In that year, two subaqueous tunnels were commenced: a small 5 ft. by 4 ft. tunnel at Antwerp Docks, and the much larger scheme under the Hudson River, New York. This comprised two parallel tunnels, 18 ft. by 16 ft., which were to be lined with brickwork. The tunnel was driven with a shield and compressed air. As with Brunel's tunnel, formidable difficulties were encountered. The soil consisted of mud so soft that the shield could be driven forward without preliminary excavation, but for a length of 750 ft. a reef of rock was met with, 1 ft. to 16 ft. high above the bottom of the tunnel. The cover was also small, and two serious blows occurred when the river broke in and flooded the tunnel. Various devices were tried; a blanket of clay was deposited on the bed of the river; heat was applied to bake and harden the mud at the working face; and a cast-iron lining was

adopted in place of brickwork. An indication of the difficulties is given by the fact that the work, commenced in 1879, was suspended in 1882 for lack of funds; it was restarted by an English company in 1889 and stopped again two years later for the same reason. Finally, it was restarted in 1902 and completed in 1904.

In 1888, the shield in combination with compressed air was applied to two subaqueous tunnels: the 10-ft. diameter Lake Vyrnwy aqueduct tunnel under the river Mersey, and the 21-ft. diameter Sarnia tunnel, where the Grand Trunk Railway crosses the St. Clair River. No exceptional difficulties were met with in either case, and both tunnels were successfully completed.

The 27-ft. diameter Blackwall tunnel, carrying a roadway under the Thames, which was built during 1891-97, shows several features of interest. The tunnel was 3,116 ft. in length and was driven through gravel. The shield was fitted with a double diaphragm pierced by four doors and twelve chutes, each provided with an airlock. The face was fitted with sliding shutters. The intention was to maintain a higher pressure at the working face than in the tunnel and also, if desirable, to vary the pressure in the various pockets of the shield. This differential pressure, however, was not employed. The chutes, each serving a separate pocket at the working face, discharged on to platforms arranged at various levels on a travelling gantry, and thence the spoil was tipped into wagons running below. The tunnel, for a length of 150 ft., had a cover of only 5 ft. 6 in. of gravel below the bed of the river, and over this length a blanket of clay, 15 ft. thick, was dumped, which was undoubtedly efficacious in preventing blows, though two or three did actually occur. The length of the tunnel between shafts was 1,220 ft. and the average rate of advance was 22½ ft. a week.

The Scheldt Tunnel, Antwerp, was a 30-ft. diameter roadway tunnel, 5,801 ft. in length, for vehicular traffic. There was also a smaller tunnel for pedestrians. The work was commenced in 1931. The tunnel was driven through fine saturated sand with the use of a shield and compressed air, the pressure averaging 18 lb. to 20 lb. per square inch, with a maximum of 30 lb. per square inch; the lining was of cast iron. The average rate of advance was 10 ft. a day or, say, 55 ft. a week, with a maximum of 125 ft. a week; a remarkable increase over the rate attained at Blackwall.

The under-river portion of the Mersey tunnel was completed in 1934, and was 5,204 ft. in length and of 46 ft. 3 in. external diameter, and carried a 36-ft. roadway beneath the River Mersey. Two pilot tunnels, one above the other, were first driven on the centre line of the main tunnel, and also a drainage tunnel, the pilot tunnels being dismantled as the main tunnel advanced. The tunnel is in fissured and water-bearing sandstone, but in one place it came to within 3 ft. of the top of this rock. Excavation was first tried with drills and rock-breakers, but it was found too slow and costly, and explosives had to be used. The seams in the rock were closed by cementation and chemical consolidation in advance of the excavation, a process which was also applied in sinking the shafts; the lining was of cast iron. The length of tunnel on the landward side of the river shafts was semicircular in section. It was driven with a roof shield and was lined with cast-iron or steel ribs and concrete.

The East River Tunnel, New York, only recently completed, comprises two 31-ft. diameter roadway tunnels, driven through earth, mud, rock, and disintegrated rock. A heavy clay blanket was first deposited over the two main channels of the river. The maximum air pressure used was 37½ lb. per square inch; the rate of driving averaged 35 ft. a week. A comparison of this tunnel and the Hudson tunnel indicates the great strides made in the art of subaqueous tunnelling in 50 years.

The conditions under which subaqueous tunnels are driven vary so widely that it is difficult to generalise on the subject of speed. I may, however, cite a few figures for the average rate of advance: Sarnia Tunnel, 65 ft. a week; the Brooklyn Tunnels, 45 ft. to 52 ft. a week; and the Rotherhithe Road Tunnel, 31 ft. a week for the first half of its length and 59 ft. a week for the second half. These and other instances indicate an average rate of 50 ft. to 60 ft. a week under reasonably good conditions. In mixed ground, where the top of the tunnel is in soft material and the lower part in rock, progress is considerably slower. In soft material, much higher rates have been obtained. In the 29-ft. diameter Holland tunnel under the Hudson river, where the material was silt, a rate of 112 ft. a week was maintained in 1924.

(To be continued.)

AMERICAN OIL INDUSTRY.—During the week ended November 22 a new high record was set up in production by the petroleum industry in the United States. The output averaged 4,336,850 barrels daily, an increase of 250,000 barrels over the total for the preceding week.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

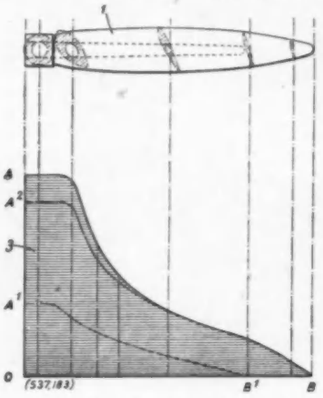
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

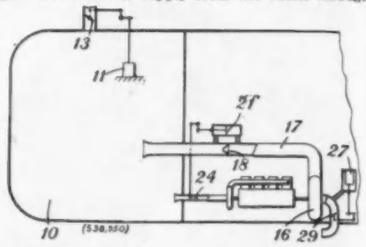
AERONAUTICS.

537,183. Moulding Airscrew Blades. The De Havilland Aircraft Company, Limited, of Hatfield, and E. P. King, of Mill Hill. (4 *Figs.*) December 11, 1939.—The invention is concerned with the moulding of airscrew blades from "compressed wood" or similar fibrous compositions. The hollow moulded airscrew blade 1 has greater density at the root end. A master pattern sheet 3 is shaped in accordance with the varying volume per increment of length of the blade, the method of determining the shape of the master pattern being as follows: At selected points along the blade, the cross-sectional area of the solid portion of the blade is computed, and then the amount of wood veneer of given initial thickness necessary, when compressed, to fill this area. From these latter values are then obtained the corresponding widths of a single sheet (in compressed state) having the same volume as the blade itself. The degree of compression in the moulding process being established, the corresponding widths of uncompressed single sheet are then determined. The width, at the selected points, of the master pattern for the individual pencils is then



given by dividing the values obtained for the single sheet by the number of pencils to be employed. These final values are then plotted on a graph of which the abscissæ represent the radius of the airscrew blade and the ordinates represent the width of the sheet, giving the curve A^2 B. The curve A^1 B^1 represents the volume of the hollow portion of the blade. The actual shape of the master pattern, which is the area under the curve A B, is now determined in accordance with the grading of density which is desired in the final blade. The area between the two curves A B and A^2B represents the extra amount of wood veneer to give the required increase in density at the root. In moulding the blade, a number of pencils cut from the master pattern O A B, rolled and impregnated with a phenol-formaldehyde resin, are stacked in the mould around the core. The assembled mould is placed in a power press and heated under pressure. Any part of the blade can be provided with a comparative increase in density by modifying the curve A B at the desired sections. Thus, to reduce tendency to "flutter," selected pencils are placed in the mould at the leading edge of the blade and are formed from a master pattern in which the height of the curve A B is increased above the base-line O B. (*Accepted June* 12, 1941.)

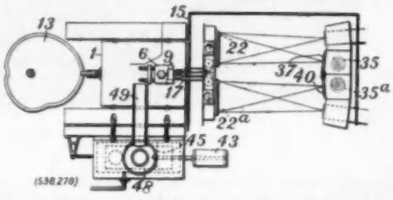
538,950. Air-Supply System for High Altitudes. The Bristol Aeroplane Company, Limited, of Bristol, F. Nixon and E. I. B. Marples, of Bristol. (3 *Figs.*) January 20, 1940.—The system is designed to maintain a constant-pressure air supply in an aircraft cabin at high altitudes. Within the cabin 10 is a collapsible bellows 11 responsive to the pressure within the cabin, and an outlet valve 13 is connected with the bellows so as automatically to maintain the pressure within the cabin at altitudes at which supercharging is necessary. An air supply to the cabin is provided by a supercharger 16. In order to maintain a uniform supply of air to the cabin under all conditions, an orifice 18 is provided in the air delivery pipe 17, which creates a pressure-drop in the pipe depending on the volume of air passing through it and from each side of this orifice connections are taken to a chamber containing a flexible diaphragm 21. The engine draws its air supply from the cabin through a



throttle-valve 24 controlled by the diaphragm so as to maintain a substantially uniform delivery of air from the blower. An additional or alternative control is provided on the intake to the blower 16 by means of a collapsible bellows 27, which is affected by the pressure in the intake, and which controls the intake valve 29. (*Accepted August* 22, 1941.)

MISCELLANEOUS.

538,278. Gauging Machine for Tapered Rollers. British Timken, Limited, of Birmingham, and R. Treen, of Birmingham. (7 *Figs.*) January 20, 1940.—The gauging machine shown is for gauging tapered rollers for taper angle and surface straightness. The gauging table is a ball mounted slide 1 on the main bed. The table carries a pivoted positioning plate 6 having two V-shaped vertical ribs for engaging the taper roller 9 to be tested. The positioning plate is adjustable to bring the outer edge of the roller into a plane at right-angles to the longitudinal axis of the apparatus. The rollers are fed into position from a hopper, and the work-table is reciprocated by a cam 13 driven by the hopper-feed. To the right of the work-table is a measuring box 15 containing electric lamps, reflectors and photo-cells. Aligned contacts 17 engage the roller 9 at three points along its surface on the side opposite to the positioning plate 6. The contact nearest the larger end of the roller is fixed, while the other two are free to slide. The latter control the orientation about their vertical axes of two concave mirrors 22, 22*a*, which respectively reflect the images of two slits of light on to two photo-electric cells 35, 35*a*. Each cell is totally enclosed by a cover, the front of which is fitted with a slotted diaphragm. The diaphragm 37 has a slot of fixed width, but the diaphragm itself can be displaced bodily in a lateral direction by means of shims. The other diaphragm 40, how-



ever, is in two parts laterally adjustable to vary the width of the slot between them. The photo-cell 35 has its anode loaded from an external source, and when the beam of light from the mirror 22 falls on the cathode, a primary current flows which operates a relay to switch on the loading potential to the second cell 35*a*. When the beam from the mirror 22*a* falls on this cell, a current flows through the latter and energises a relay which switches on current to a solenoid 43. The solenoid core is connected to a selector slide 45 which moves beneath a selector hopper 48. The latter is positioned beneath a sloping chute 49 overhanging the work-table 1, and the slide 45 carries on its underside an acceptance chute and a rejection chute. When the solenoid is energised the slide 45 brings the acceptance chute beneath the hopper 48 against the action of a return spring. The work-table 1 is then drawn fully back by its cam, and an ejector pushes the roller into the chute 49 and so into the tray for accepted rollers. If the angle of taper of the roller is incorrect, the beam will not pass through the slot on to the photo-cell 35, so that both cells 35, 35*a*, will be electrically unstimulated. The solenoid is not, therefore, energised and the slide holds the rejection chute under the hopper 48. If, however, the angle of the roller is correct from end to end but the sides are not within the limit for straightness, the beam will not fall on the cell 35*a*, and the solenoid 43 will not be energised and the roller will again be rejected. The adjustable slot in the diaphragm 40 can be set so that a slightly barrel-shaped roller is passed. (*Accepted July* 28, 1941.)